The AMSAT® Journal

Volume 39, Number 4 July/Aug 2016

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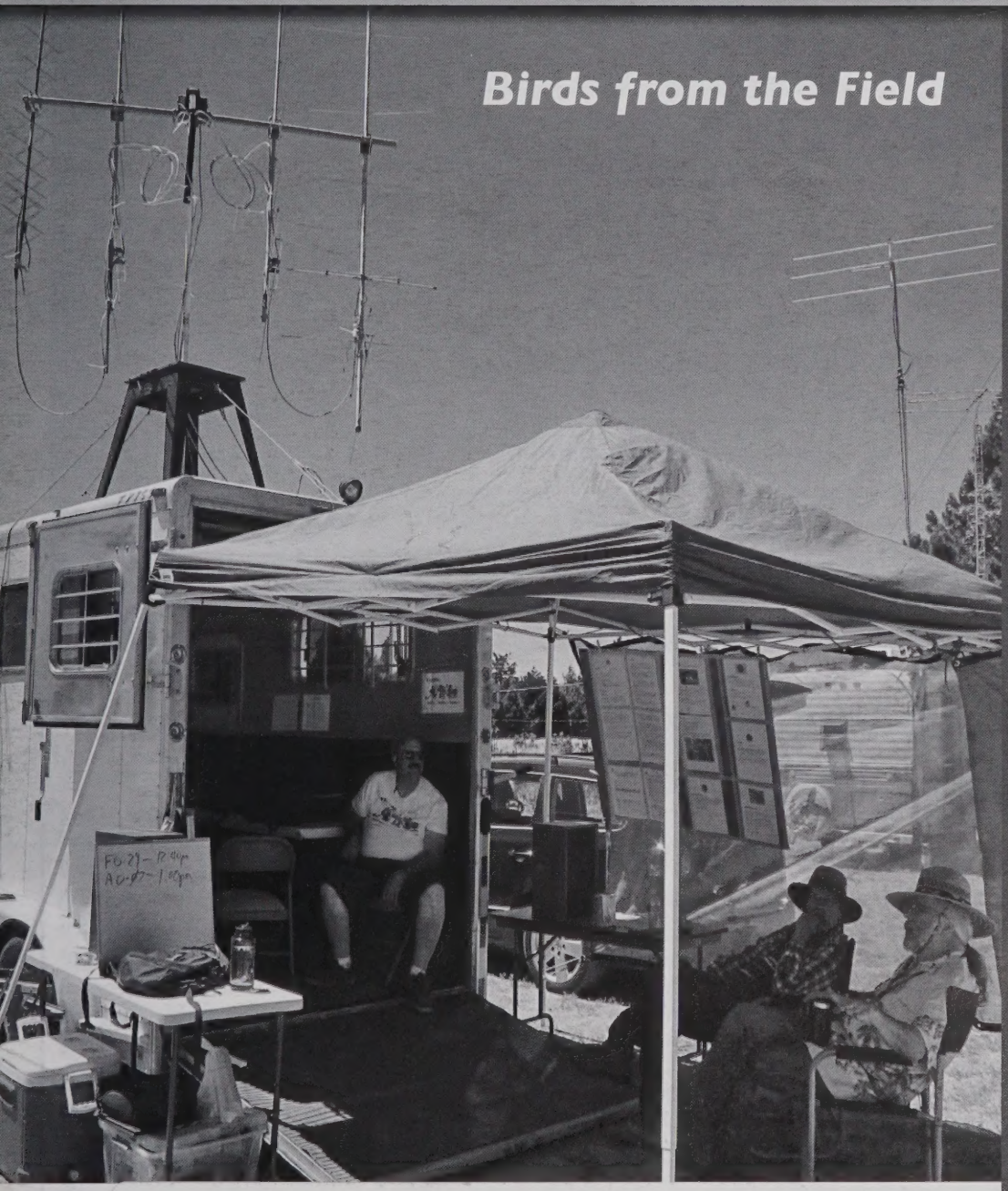

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From portable handheld antennas to command/control arrays, M2 Antenna Systems can supply what you need.
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2M CP YAGI
436CP16
70CM CP YAGI
The LEO-Pack
Are you ready for Fox 1C & 1D? Missing out on all the action on the latest birds? The M2 LEO-Pack is a great solution for LEO communication. You do not need an elevation rotator for casual operation, but elevation will allow full gain over the entire pass.
The 2MCP8A is a circularly polarized antenna optimized for the 2M satellite band. The 436CP16 has been designed for an optimum match and gain at the 70CM satellite band. A perfect system for a small home or portable system.
*See our review, QST March 2016 page 60.
Need a bit more link margin? The 2MCP14, 2MCP22, 436CP30, 436CP42 antennas are HEO capable. Optional items are also available like the CB60 fiberglass cross boom, power dividers, polarity switches, phasing lines and complete H-Frame assemblies.
2M-440XP-SS
2M 440 XP YAGI
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AMSAT Announcements

The AMSAT Journal Needs Your Words and Wisdom

The AMSAT Journal is looking for interesting articles, experiences and photos to share with other AMSAT members. Writing for the *Journal* is an excellent way both to give back to the AMSAT community and to help others learn and grow in this most fascinating aspect of the amateur radio avocation.

Find a quiet place, sit yourself down, get out your laptop or pick up a pen, and ...

1. *Launch* your inner writer;
2. *Downlink* your knowledge and experiences to others by
   - Sharing your adventures in the "On the Grids" column or
   - Describing your AMSAT career in "Member Footprints;"
3. *Transmit* lessons learned from operational and technical projects;
4. *Log* some of your more interesting passes across the sky; and
5. *Boost* others to a higher orbit of know-how and experience.

After your article lands in members' mailboxes, and the kudos start arriving for your narrative payload, you can enjoy the satisfaction of knowing you've elevated the collective wisdom of AMSAT to a higher trajectory.

Send your manuscripts and photos, or story ideas, to: **journal@amsat.org**.

Our editors are standing by!

AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.

Radio Amateur Satellite Corporation (AMSAT-NA)
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AMSAT-NA Web site: http://www.amsat.org

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President Emeritus: Tom Clark, K3IO
Founding President: Perry Klein, W3PK

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The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. Kindly do not embed graphics or photos in your manuscript - we prefer receiving those as separate files. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations.

Apogee View

Barry Baines, WD4ASW
President

The past few months have been hectic for AMSAT, and, as we head into the fall, the pace will continue to escalate. This is good news, as several of our projects will soon be in orbit as we lay the foundation for future activities.

Before highlighting recent developments, however, I need to take a moment to note the passing of Douglas Loughmiller, W5BL. Doug served as President of AMSAT starting in 1988, among other senior leadership positions. AMSAT Board Member Bob McGwier, N4HY, writes about his reflections on Doug that appear in this issue. The ARRL noted Doug's passing in the "ARRL Letter," as did AMSAT through ANS, but Bob provides a personal perspective about AMSAT's fourth President. Doug loved amateur radio and touched many in our hobby and within his community.

Doug passed away on July 22, 2016, and the funeral was held on July 27, in Paris, TX. I happened to be in North Texas that week, so I drove to Paris from Southlake to attend the funeral at the Starrett Funeral Home. Also attending were several other AMSAT members, including Bill Reed, NX5R, and his wife, Sharon, plus Bob Stricklin, N5BRG. Greg Jones, WD5IVD, also attended. Greg is a former President of TAPR and like Doug worked at Surrey Satellite Technology in Surrey, England.

The funeral home's parking lot was full of vehicles with call sign license tags and mobile antennas. Clearly, many from the Texas amateur community turned out. Doug made a difference for AMSAT and amateur radio. He passed away at age 60. R.I.P.

As an AMSAT member, you received an envelope that contains the ballot and candidate's statements for this year's Board of Directors election. Please take time to review the candidates' statements and decide whom you'd like to serve on the board. The deadline for receipt of ballots in Kensington is September 15, 2016. As an AMSAT member, one of your privileges and duties is participation in the Board of Directors election process.

A letter from the AMSAT Board of Directors is also included in that envelope and provides a mid-year review of our current projects. Please review that letter as it provides a succinct status report on our Fox Projects and Phase 4-B. We continue to look forward to the upcoming launches of Fox-1Cliff and Fox-1D during the September 1 to November 30 timeframe. RadFxSat-1/Fox-1B is being finalized for delivery later this year for a launch expected to take place in the first quarter of 2017.

One item that bears repeating is to ask for your contribution to help support AMSAT's continuing efforts to keep amateur radio in space. AMSAT has spent considerable resources to purchase commercial launch services for Fox-1Cliff and Fox-1D, in addition to $100K for a payload accommodation study for Phase 4-B in order to have Millennium Space System assess the impact of the amateur payload to the satellite and the primary payload. As the board letter notes, the results of that study reaffirm the feasibility of placing an amateur payload on the spacecraft.

A contribution form is included with the board letter. Please consider giving generously to provide the resources necessary for AMSAT to continue supporting amateur radio in space.

The letter also notes the upcoming AMSAT Space Symposium at Sea aboard the Carnival Liberty. An included flyer provides details about the cruise as well as a FAQ. Time is starting to run out, so please make your reservation with Carnival as soon as possible to ensure you secure the accommodations that you desire.

Please note, first, the flyer enclosed with the ballot has a typo regarding the AMSAT group code from Carnival; the correct group code is 8Z0FR5, as stated on the AMSAT website. Second, the Carnival cruise payment does NOT include registration for the Symposium itself. The Symposium registration fee is $40.00 per individual and includes a bound copy of the Proceedings of the AMSAT-NA 34th Space Symposium & Annual Meeting. Symposium registration must be submitted either by: (1) completing and mailing the registration form included with the ballot, along with your payment (check or credit card information); or (2) registering through the AMSAT Store with an online payment. One difference between this year's Symposium and prior symposia held at a hotel is that all of your meals are included in the cruise package. Thus, everyone (registrants and their families/colleagues) is invited to the AMSAT Banquet. We do ask in the Symposium registration process that you specify the number of individuals in your

group who plan to attend the banquet so that we can ensure sufficient space.

Our banquet speaker is Scott Higginbotham, Mission Manager in the NASA-KSC Launch Services Program Office at Kennedy Space Center, Florida. Scott is a key individual engaged in NASA's CubeSat Launch Initiative (CSLI), the program that encourages schools and not-for-profits to seek launch opportunities for their CubeSats that meet NASA mission objectives. Fox-1A, RadFxSat/Fox-1B, and RadFXsat/Fox-1E all have been accepted by CSLI, with AMSAT making the submission for Fox-1A. Vanderbilt University's Institute for Space & Defense Electronics (ISDE) made the submissions for RadFxSat-1/Fox-1B and RadFxSat-2/Fox-1E. As Mission Manager, Scott has worked directly with AMSAT on the ELaNa XII (Fox-1A) and the upcoming ELaNa XIV (RadFxSat-1/Fox-1B) missions.

As our banquet speaker, Scott is expected to share his perspective on the increasing use of CubeSats, future trends in CubeSats and small satellites, and the impact of CubeSats on science and education. As Scott will be onboard the cruise, Symposium attendees will have ample opportunities to meet him and gain some insight on the future of small satellites under CSLI. We look forward to having Scott join us for our Symposium.

The regular Field Ops Meeting will provide an opportunity for our Area Coordinators attending the Symposium to get together and share experiences and ideas on representing AMSAT locally and to encourage new satellite operators. At this point, we expect the meeting to take place in a different venue following breakfast. The registration form asks that you specify the number of people from your group who will be attending the Field Ops gathering so that we can ensure enough space.

The AMSAT Board of Directors Meeting will take place Wednesday, November 9, and Thursday morning, November 10, at the Doubletree by Hilton Galveston Beach. The board meeting is open to all AMSAT members and other interested observers, although the board may go into closed session for a portion of the meeting when necessary. AMSAT has a small block of rooms at the Doubletree to be used primarily by AMSAT Senior Leadership on Tuesday and Wednesday evening. Once these participants make their reservations, we will open the remaining rooms to AMSAT members who presumably wish to attend the board meeting as observers. Check the Symposium pages on the AMSAT website for the block code once it is released. Note that the special room rate is available only for the period November 8-10 and is not available upon return from the cruise on Monday in Galveston. Given that the Symposium, itself, is not taking place at the hotel, we were mindful not to overcommit on room bookings since it is unclear how many individuals would arrive in Galveston several days early to attend the board meeting.

My wife, Kathy, WD4ASX, and I are looking forward to this unique Symposium @ Sea. Given the reservation count, we expect a large number of individuals will be involved with Symposium with a large number of family members/significant others coming along. We're seeing a level of international participation as well, with representation from the United Kingdom, Germany, and Israel already booked for the cruise.

K8BL Awarded Satellite WAS

ANS-164 (June 12, 2016)

38 Years of Satellite Contacts Nets Satellite WAS for K8BL

Congratulations are in order to Bob Liddy, K8BL, for achieving Worked All States via satellite and earning WAS Satellite Award #341. The contacts for his award spanned 38 years. Bob's oldest satellite QSL card was from W7LSV in Oregon, 10/13/78, for an Oscar 8 Mode A CW contact.

Bob's last state contacted was North Dakota, W0N, for a contact with Wyatt, AC0RA, via SO-50 FM on 11/13/15.

An AMSAT member since 1979, Bob wrote via the amsat-bb, "Earlier this year, I was going through my paper QSL's getting ready to make some submissions for various ARRL Awards at the Dayton Hamvention. Sorting through the cards, I made a stack of Satellite QSL's. I started to notice that I had quite a few states confirmed and wondered if I was finally close to WAS even though I wasn't really in the hunt very seriously. Would you believe I had them ALL worked but was only missing a QSL from Vermont?!

Happily, it was Nick, KB1RVT, who I KNEW was always good for a confirmation, which he quickly returned confirming our contact via SO-50 FM on 11/4/16. 50 Paper QSL's, 38 Years! WHEW! Thanks to all who helped."

Engineering Update

Jerry Buxton, NØJY
Vice President, Engineering

Fox-1 Update

We are nearing the end of the planned four Fox-1 FM CubeSats. RadFxSat (Fox-1B) is on the desk in Fox Labs, undergoing final flight functional tests. It will ship to Tyvak for shock testing by the time you read this. In mid-August, RadFxSat will be transported to National Technical Services in Orlando for vibration and bake out testing. Spacecraft delivery is scheduled for November, with launch still scheduled for January 20, 2017.

If that date holds, with the expected fall launch of Fox-1Cliff and Fox-1D, we will have launched all four of the Fox-1 satellite series in a 15-month period. A good ending to the original project, we hope to have all four working for you in the next eight months!

The original project envisioned four satellites. RadFxSat-2 (Fox-1E) is an extra that is made possible by the leftovers from the first four. We have one set of battery cells left, along with several PCBs for each system. As you hopefully are aware, we are working hard to incorporate a linear transponder on RadFxSat-2/Fox-1E. The launch opportunity for Fox-1E came along a little sooner than we had anticipated. Spanning several years from selection to launch manifest for Fox-1A and RadFxSat/Fox-1B, our selection this year put us at the top of the list. As a result, we are looking for a launch in late 2017 or early 2018 – about a year behind RadFxSat/Fox-1B. That puts a pretty good time crunch on developing, testing, and integrating a whole new RF system on the bus. Our volunteer team members are working hard to make it a reality!

P4B and P5

Much work is being done on the AMSAT Ground Terminal, and I hope that you are reading the weekly updates that Michelle posts on YouTube. Search on YouTube for abraxas3d. The ground terminal is not subject to ITAR, and Michelle does a pretty good job sharing a lot of information with weekly updates. As far as the P4B satellite, as you heard or read in the reports from Dayton, I'll just say it is "still in progress."

I decided that P5 was a better reference to the CQC mission since the purpose really is to gain us our first Phase 5 satellite, designating a lunar or interplanetary mission.

As with many past amateur radio satellites, we will be a part of another mission, after which the satellite will be turned over to AMSAT for amateur radio use. The amount of knowledge gained from this project is equal only to the excitement of having the first amateur radio satellite orbiting the Moon!

P5 draws upon some RF and SDR feature/functionality from P4B. As with the Ground Terminal, which should serve several satellite missions, the development of P4B and P5 are intended to complement the missions and further our growth. P5 is proceeding "nominally" – which is to say as anticipated – with the next one of the CQC ground tournaments coming up in October.

ASCENT has spawned another working group that is exploring software and hardware for an SDR package comprised of a Xilinx Zynq-based SDR and custom TI Hercules-based Supervisor/Interface Board. The capabilities of an FPGA SDR can provide multiple band capability for many types of satellite missions. In addition, the knowledge gained can be applied to other hardware either built or bought.

Iron Men

AMSAT is primarily an "iron man" organization in the sense that we have a lot of engineering work that is taken on by a relative few volunteers. The measure of work and stress probably can't be communicated easily, but it takes its toll on our volunteers. I would ask you to consider, if you have any interest, helping get more satellites in orbit.

You may wonder what you can do, and not everyone is an engineer. We do need engineers. However, other tasks need to be done besides the schematics and solder, and perhaps some of you are in a position to help. A little help can go a long way if you can commit to getting a certain task done. Even a few individuals coming together to work on something helps achieve the work necessary without any one, or just a few individuals, having to work long hours to complete a task. Please look at the Engineering want ad on the back page of the Journal and, if you would like to help, consider joining us to get RadFxSat-2 in orbit and work on other exciting projects!

Please note: if you submit the form to volunteer, give us a few weeks to respond. I am the sole responder to those requests, and I am as busy as a one-armed paper hanger with all of the projects we are undertaking. We do want your help!

More News Coming

Another important update is the launch of Fox-1Cliff and Fox-1D, as well as the successful completion of RadFxSat/Fox-1B. Additionally, I should be able to provide some details about the RadFxSat-2/Fox-1E mission. Our first ELaNa XX meeting took place on July 21 and, while I now have some preliminary details about the mission, I will share these and other interesting updates in the near future. In the meantime, keep working the birds and spreading the word that more are on the way!

Chirps

[From the AMSAT-bb and Twitter]

Question asked by Jim White (jim@coloradosatellite.com) on July 1, 2016:
In the past I've used satellite tracking programs that allowed a 'lead' setting. That is, you could tell the software to lead the satellite by a few seconds. That did a pretty good job of keeping the sat in the beam width when the azimuth was changing quickly. I'm not finding that setting in SatPC32. Is there one, or will another setting accomplish the same thing?

Answer by Erich Eichmann (**erich.eichmann@t-online.de**) on July 1, 2016:
There are the following options in menu "Rotor Setup" that could be used to update the azimuth and elevation antenna positions:
a. in time increments, say 3 seconds or less,

b. when the satellite's position (azimuth or elevation) changed by a certain CONSTANT amount of degrees (dead band), say 3 degrees or less. The program then updates both rotators every 3 seconds or whenever the azimuth or elevation changed by a fixed 3 degrees or more. Then it positons the antennas a half step in front of the current satellite position. So, the satellite will run through the "focus" of the antenna.

There is a sub option of b., "gain related." When the elevation of the satellite increases, the azimuth position of the satellite changes very quickly and the azimuth antenna positon will be updated very often. On the other hand the horizontal opening angle of the antenna becomes virtually wider, following a cosine function (at 90 degrees the elevation azimuth is meaningless). This feature utilizes this effect to reduce the number of horizontal updates without loss of gain. Also, the signal is stronger at high elevation angles, due to the smaller distance to the satellite. So, with a small update step, data should not be lost, even with the setting "gain related." That all is described in the manual (menus "Rotor" and "Rotor Setup").

Member Footprints
Fernando Ramirez-Ferrer, NP4JV

Previous callsign: WP4LGN,

Grid Square: DM41, Nogales, AZ

Favorite Satellite Contacts:
FG8OJ, KL7XJ, PJ2/HB9WDF

First Satellite Contact: VA7EWK/3

First Satellite Ground Station:
3 element "tape measure" Yagi and a Baofeng UV-5R handheld

Current Satellite Ground Station:
FT-817ND, SDRPlay RSP, a pair of Chinese made HT's and an Arrow 2m/70cm crossed Yagi.

Reasons I am an AMSAT Member:
I became a member in order to support AMSAT in its goal of advancing satellite communications and to be part of the fellowship of other amateur radio satellite operators. I have been fortunate to find help and support among other "birds" enthusiasts. From words of encouragement to actual technical assistance, these individuals have helped me become a proficient operator.

Favorite AMSAT Memory:
On March 31, 2016, I completed an unscheduled contact with FG8OJ on AO-85, using a 4 W handheld radio and an Arrow II antenna. The satellite elevation was around 2 degrees and the distance between our stations, 5,282 km. The contact set an AO-85 distance record that was recently broken by FG8OJ and EB1FVQ on 4/14/2015 with a distance of 5,744 km.

With the assistance and support of other AMSAT members, I was able to complete the ARRL/VUCC award in 3 1/2 months.

Favorite Topics:
Reading about other roving operators' experiences and new AMSAT projects.

AMSAT 2016 Space Symposium Cruise

The 2016 AMSAT Space Symposium will be held aboard the Carnival Liberty on November 10-14. Your family, friends, or significant other will want to join you at the Symposium this year!

2016 Highlights

Cruise Departure
Galveston, Texas, near both Houston airports (IAH & HOU)

Two full days at sea
Symposium presentations and annual meeting while at sea

One day in port
Sightseeing and other activities in Cozumel, Mexico

Fun for everyone
Great food, activities and fun for family and friends

This year's cruise ship venue offers an environment for significant others, families, and friends to attend the AMSAT Space Symposium with you. Many activities are available on a cruise ship, including musical and theatrical performances, comedy, dancing, and casino gaming. During the stop in Cozumel there are many onshore activities and excursions available for your pleasure.

The Space Symposium will include detailed presentations on current and future AMSAT satellites, the Five and Dime Ground Terminal, satellite design and construction, satellite launch and deployment, operating experiences, Amateur Radio on the International Space Station, and ideas for future projects. The annual meeting will highlight recent activities within AMSAT and discuss some of our challenges, accomplishments, projects, and any late breaking news.

The approximate cost of the cruise is $389 per person for an inside cabin, double occupancy, for 3 nights and meals, plus tax. You can upgrade your accommodations for an additional cost. Reservations require a $150 deposit; make your reservations soon as there are a limited number of cabins set aside for AMSAT. The telephone number to book is (800) 438-6744, ext. 70005. International number is +1 (305) 599-2600, ext. 70005. The group name is AMSAT and the group code is 8Z0FR5. Please utilize the group code as this directly benefits the Symposium and the amenities we are able to offer the attendees.

For additional information, an FAQ, and up-to-the minute details on the AMSAT 2016 Space Symposium Cruise, visit the AMSAT website at www.amsat.org.

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WEB
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martha@amsat.org

2016 AMSAT Symposium Cruise Information

For those considering attending the 2016 AMSAT Symposium, the following additional information may be helpful.

Telephone numbers to book the cruise:

USA: 1-800-438-6744 - Extension number 70005.
International: +1 305-599-2600 - Extension number 70005
Note: The International line is not available on Saturdays & Sundays.
Group name: AMSAT Group code: 8Z0FR5.

The Carnival cruise fare for the AMSAT 2016 Symposium Cruise:

You may choose any type of cabin at any rates Carnival currently offers. Rates may vary based on the time of year you make your reservation. AMSAT recommends making your reservation soon to ensure there is ample space aboard the ship. You may purchase optional trip insurance (based on the cabin you select) and to pre-pay for any service gratuities.

Carnival Cruise fare does NOT include the AMSAT Symposium fee:

A fee of $40 per person applies to those who will attend the Symposium technical presentations only. Family members may attend all other events for free. The registration form is available from the AMSAT office or store website.

Finding the November 10 cruise on the Carnival website:

The cruise will be listed under the "Western Caribbean" destination, not Mexico.

Choosing dining times:

Late dining is 8:15pm, and the recommended time to eat with AMSAT attendees. Group members who chose this time will be seated in the appropriate dining area.

Attire in the main dining room:
https://help.carnival.com/app/answers/detail/a_id/1093

Dining options on board Carnival cruises (some are ships-specific):
https://help.carnival.com/app/answers/category/c/467,468

You may use promotions offered by travel agents instead of booking with the AMSAT group code:

However, there is a direct impact to AMSAT and the Symposium event if you do not use the group code and book individually. For each group participant, Carnival compensates AMSAT with amenities and event features. This is used to keep costs low and is factored into our Symposium registration fee. It also limits AMSAT's ability to monitor the number of rooms booked for attendees use in planning purposes. Please consider booking your cruise with our group code.

No limitations as to a particular cabin type:

You should book using the group code as there are specific amenities offered to AMSAT.

Transportation options between the airports and the cruise terminal:

Three options are available –

1. Purchase a round-trip transfer service from Carnival. This will be on a bus reserved for all cruise ship passengers.
2. Utilize a local service such as SuperShuttle: http://www.supershuttle.com/Locations/HoustonHOU
3. Taxi service from the airport. This is the most costly option.

Online availability of Symposium Presentations:

It is unlikely that the presentations will be made available immediately during the Symposium. However, they will be made available via YouTube or other media as soon as they have been edited for publication and proper authorizations obtained.

Online availability of the AMSAT General Meeting:

The unique nature of this venue requires physical presence to attend the AMSAT General Meeting. However, a recording of the meeting will be made available afterwards.

Amateur radio operation on board the ship:

Generally, Carnival allows operating, but specific permission is being sought to secure our ability to work satellites from the ship.

Information on internet and cellular phone access available on the ship:
https://help.carnival.com/app/answers/detail/a_id/1152/~/carnivals-wi-fi-service-and-hub-app, https://help.carnival.com/app/answers/detail/a_id/1129

For more Carnival-provided help and information:
https://help.carnival.com/

Online check-in for the cruise:
https://help.carnival.com/app/answers/category/c/173,168

Policy on tipping:
https://help.carnival.com/app/answers/detail/a_id/1123

FoxTelem Version 1.04 Changes

The most recent changes to the software fit into the following categories:

1. Full support for Fox-1Cliff, Fox-1D and RadFXSat including better High Speed decoding and a better find signal algorithm.

2. Additional analytical capabilities so you can plot one telemetry variable against another. I hope this will inspire more people to analyze the telemetry from the spacecraft and post comments on what they see. I have put some of my own thoughts online here: **www.g0kla.com/workbench/2016-05-07.php.**

Enhanced tools to analyze your ground station with SkyPlots for satellite measurements like Signal to Noise ratio and graphs for pass measurements. Skyplots in particular need a bit of explanation, so I have written more details here: www.g0kla.com/foxtelem/skyplot.php

You can read a full list of the changes here on github:
github.com/ac2cz/FoxTelem/issues?q=is%3Aissue+milestone%3A%22Release+1.04%22+is%3Aclosed

73,
Chris E. Thompson
G0KLA / AC2CZ

AMSAT Field Day Results

Bruce Paige, KK5DO
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Compared to previous years, this year's AMSAT Field Day involved many more satellites and modes. In fact, we had the most satellites and modes since I have been tracking this data.

We had seven more satellites than last year for a total of 16. The number of each satellite's modes determines the number of "satellites." SO-50 has one FM transponder and gets counted as one satellite, whereas AO-07 has two modes, SSB and CW, and gets counted as two satellites.

There were no ISS voice contacts this year, however, WD9EWK made a digital contact. Only one contact was made on NO-84 CW by WD9EWK, one contact on AO-7 CW by N4EH and one contact on XW-2A CW by W6PA.

The number of participating AMSAT Field Day stations has remained pretty constant over the years as evidenced by the table below. QSO count has dropped to almost the mean of 360.6 QSO's over 12 years. All the data from Table 1 below can be found at http://www.amsat.org, click on Events, then Other, then Field Day and Statistics.

And.... The winners for this year are the Huntsville Amateur Radio Club, K4BFT, with 83 points. The San Lorenzo Amateur Radio Club, K6MMM, took second place with 46 points, and third place goes to W2GSB with 34 points.

A few stations operated from home with both emergency power and commercial power. They were (by call area) George Carr, WA5KBH, Frank Westphal, K6FW, and Robert Hinshaw, N6UK – all on commercial power. Paul, N8HM, was on battery power and took first place for a home station on emergency power with 83 points (tying K4BFT's score).

The 16 satellites in use this year were SO-50 (FM), LilacSat-2 (FM), AO-7, AO-73, FO-29, XW-2A, XW-2C, XW-2F (all SSB and CW), NO-84 (Digital), and the ISS (Digital). The majority of contacts (130) were on FO-29 SSB. Next most used satellite was XW-2A SSB with 66 contacts followed by XW-2F SSB with 60 contacts. (See Table 2.)

Participants at the Dallas Amateur Radio Club, W5FC, site had a difference of opinion about where the satellite was. As they watched the computer (Figure 1), they tried to find the satellite in the sky (Figure 2). When night set in, a few minor adjustments was all it took (Figure 3). Tom, N5HYP, served as their operator.

Figure 4 shows operator Bill, W1PA, at the Central Massachusetts Amateur Radio Association (W1BIM) site, in a photo from one of the satellites. Well, maybe not exactly from the satellite, but Ron, N1VR, took the picture from high up.

Over at the Great South Bay Amateur Radio Club (W2GSB) location, the news media, FIOS 1, interviewed the club president, John, W2HCB (Figure 5). The story appeared on the nightly news. Susan, KD2LIA, had been licensed for less than a week and came out to give Field Day a try. Figure 6 shows her talking with Peter, W2JV.

The news media also visited the Great South Bay Amateur Radio Club, W2GSB, resulting in stories that appeared on FIOS 1 News and News 12 Long Island.

In Canada, the Lambton County Radio Club, VE3SAR, group used a really impressive antenna system (Figure 7), with two co-phased home brew Arrow style antennas built by Art, VE3GNF. Figure 8a shows Art operating the club's great looking station while Bob, VE3RSI, looks on.

The Lambton County club also was honored with a visit from its local Member of the Canadian Parliament. In Figure 8b, former AMSAT President and current Treasurer, Keith Baker, VA3KSF, helps The Honorable Marilyn Gladu log a contact with an Alabama station.

Meanwhile, operators at VE2ARC had their station setup with another impressive antenna system (Figures 10 and 11).

Patrick, WD9EWK, took to the road to operate (Figure 9), using an Yaesu FT-817ND for transmit and SDRplay for receiving. Clayton, W5PFG, operated from Fort Amarillo RV Park on the Historic Route 66. Paul, N8HM, operated from a parking lot/courtyard of his apartment complex in Washington, D.C. using two Yaesu FT-817s, preamps, batteries and an Arrow antenna. He carried everything in a camera bag. He noted many stations using excessive power causing strange things to happen with the satellites.

San Lorenzo Amateur Radio Club, K6MMM, sported its own great antenna systems (Figure 12), adding an impressive station (Figure 13), with many listening for the satellite (Figure 14). John, KJ6ZL, served as satellite operator. They noticed that during the day the satellites were quite busy but settled down in the evening. They used an audio amplifier with external speakers so visitors could hear the full-duplex conversations – always a crowd pleaser for them.

The Peruvian/North-American Radio Club, W0PNA, operated with an Arrow antenna on a tripod and a pair of Yaesu FT-897D radios. Operators used SatPC32 for Doppler correction.

	2009	2010	2011	2012	2013	2014	2015	2016
Satellites	12	12	9	9	7	12	9	16
QSO's	328	387	335	263	443	305	316	424
Stations	20	18	14	19	23	21	21	22
Points	486	505	455	329	613	357	386	448

Table 1

SO-50 Phone	AO-7 Phone	FO-29 Phone	AO-73 Phone	XW-2A Phone	XW-2C Phone	XW-2F Phone	NO-84 Digital	ISS Digital	LilacSat-2
9	5	130	39	66	52	60	1	1	6

Table 2

Figure 1 – Dallas Amateur Radio Club (DARC).

Figure 2 – DARC.

Figure 3 – DARC operator, Tom Schuessler, N5HYP.

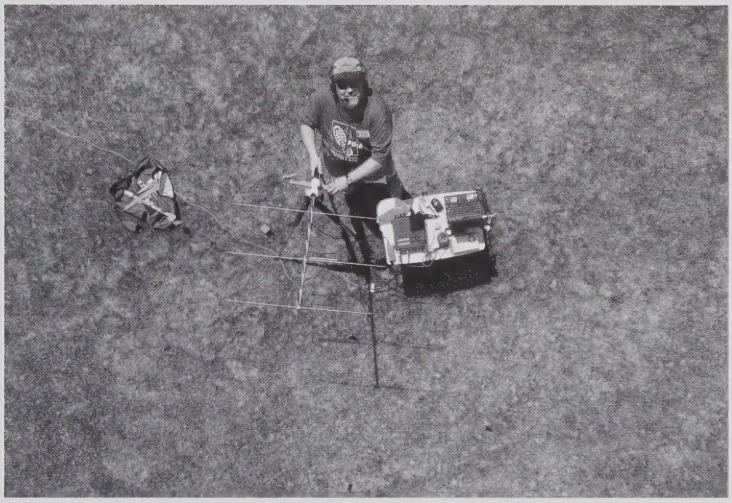


Figure 4 – Bill Acito, W1PA, Central Massachusetts Amateur Radio Association.

Joe, WA3PTV, operating the station for the Antietam Radio Association, W3CWC, found out that Field Day was not the time to try and calibrate the system for satellites. We must concur. A little preparation ahead of time makes it smoother during Field Day. Joe, K0OV, gave a report from the Hospital Disaster Support Communications System, W6PA, that they could not work many passes lower than 60 degrees because their site was located in front of the Huntington Beach Hospital which blocked them.

Steve, N9IP, worked from a campground in Rhode Island and had a great time. Dennis, KI4KNC, at the Lake Monroe Amateur Radio Station, N4EH, had his UHF transmitter repaired and was able to work birds with UHF uplinks this year.

Finally, we have the Bergen Amateur Radio Association, K2BAR, putting up its station (Figure 15) in New Jersey.

In Figure 16, you will see what XW-2F over Texas looked like at 0001 UTC on June 26. Notice something about the photo? Why are all the operations taking place in the center of the pass band instead of spreading out? Thanks to Ron, W5RKN, for this photo from his FlexRadio display.

This year I was able to get out for Field Day and visited the TEAC site in Kingwood, Texas, as well as the BVARC/ECHO/TDXS site in Richmond, Texas. I had a lot of fun writing this year's story. Our wish for more satellites was answered as well as more participants in Field Day. Hopefully, "Murphy" will not visit your Field Day site next year. But if it does, be prepared.

Here is a table of all entries received. In the case of a tie, the call signs are listed alphabetically.

	Call	Class	QSOs
1	K4BFT	4A	83
2	N8HM	1B	83
3	K6MMM	3A	46
4	W2GSB	6F	34
5	W6PA	2A	23
6	K4JJ	3A	21
7	VE3SAR	3A	20
8	K2BAR	5A	16
9	K6FW	1D	15
10	VE2ARC	2A	14
11	W1BIM	6A	13
12	WA5KBH	1B	13
13	N6UK	1D	11
14	WD9EWK	1B	9
15	WE7GV	2A	9
16	N4EH	5A	8
17	W5PFG	1B	7
18	N9IP	1A	5
19	W0PNA	1A	5
20	W3CWC	6A	5
21	WA7LAW	4A	5
22	W5FC	4A	2

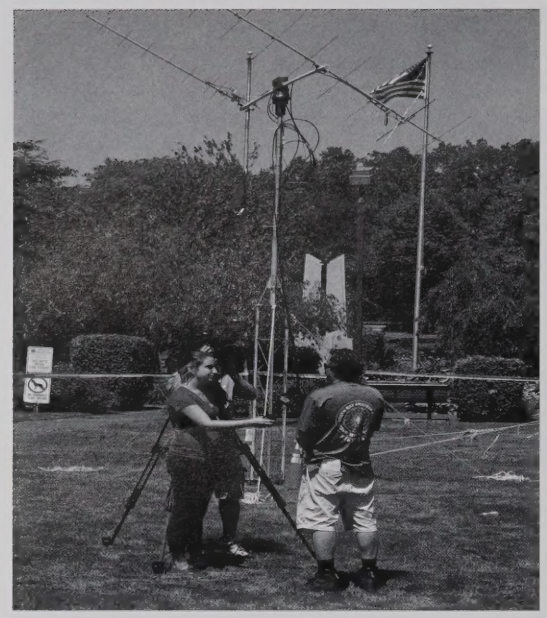


Figure 5 – John Melfi, W2HCB, Great South Bay Amateur Radio Club, being interviewed.

Figure 6 – Susan Park, KD2LIA, talking with Peter Portanova, W2JV.

Figure 7 – Lambton County Radio Club, VE3SAR, antenna system.

Figure 8a – Art Payne, VE3GNF, operating Lambton County station, while Bob Sacerty, VE3RSI, supervises.

Figure 8b – Keith Baker, VA3KSF, assisting Hon. Marilyn Gladu.

Figure 9 – Mark Maynard, N7UJI, checking out Patrick Stoddard's, WD9EWK, portable setup, along I-40 and US-66, Kaibab National Forest, AZ.

Figure 10 – Montreal Amateur Radio Club, VE2ARC, antenna.

Figure 11 – Montreal Amateur Radio Club station.

Figure 12 – San Lorenzo Amateur Radio Club, K6MMM, station.

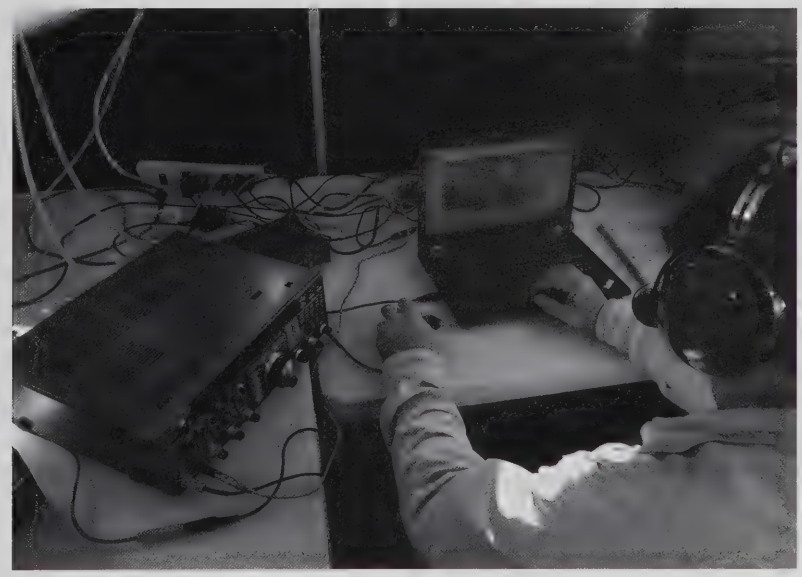


Figure 13 – Operator at San Lorenzo club station.

Figure 14 – San Lorenzo club station (Santa Cruz County, CA) operators listening for the satellite.

Figure 15 – Bergen Amateur Radio Association, K2BAR, New Jersey.

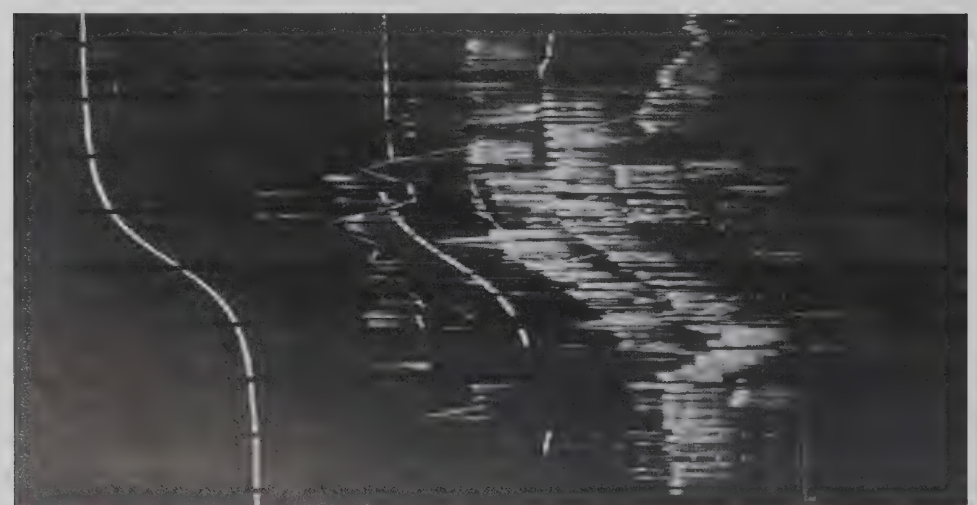


Figure 16 – Waterfall display of XW-2F over Texas on June 26. Ron Parsons, W5RKN, photo.

Digital Microwave Communications in Amateur Radio Satellites

Michelle Thompson, W5NYV
Robert McGwier, N4HY
Board Member

One of the biggest revolutions in technology has been the transition from information being represented in analog form to information being represented in digital form. This transition has profoundly affected communications and media of all types. Photography, music and video recording, documents, telephony, and computation have been fundamentally recast in formats that are compressible, storable, filterable, easily copied, and easily shared.

Digital representations are quite often a series of samples of an existing, natural, continuous analog signal. Imagine you are in charge of a ferryboat service on the Mississippi river. You can't cross with passengers when the water level is too high. You can't cross with passengers when the water level is too low. Water levels vary quickly in the South due to the complexities of the river system and the weather. You have to monitor the river closely. To help with this aspect of the river ferry business, you decide to hire a young up and coming local fellow named Huck Finn. You tell him he has to watch river levels and let the ferry drivers know when they can take passengers or when they have to tie up at the dock and wait for better conditions.

Now, Huck doesn't want to stand there for his entire shift, continuously watching the water levels go up and down. He notices that the fastest the water levels change from safe to dangerous is at least one hour. To be able to properly monitor the river, he figures he needs to check at least every half hour. So, he decides to wind up an alarm clock that sounds every half hour. Every half hour, when the alarm goes off, he'll check the river level and do whatever is required to keep the ferryboats safe. Between checks of the river, which don't take up that much of his time, Huck naps, fishes, reads, talks with his friends, doodles, and works on a couple of side ventures (**http://twain.lib.virginia.edu/huckfinn/huchompg.html**).

Huck can get away with this because he's checking at least as fast as the rate at which the river makes important changes of state. The rate of checking (sampling rate) is

determined by how that particular river behaves. Another slower-changing river might only require checking (or sampling) every 10 hours. Another more tempestuous river might be subject to flash flooding, and needs checking every 10 minutes, or possibly the installation of a bridge!

After a day of leisurely sampling, Huck has a list of river levels. This list of numbers is taken at regular intervals and describes the behavior of the river for that day. In fact, if he checks often enough, and he's willing to do some math, this pocket-sized list can perfectly recreate the behavior of the river.

For modern electronic computerized circuits, Huck's river level numbers would be converted into binary representation. This is base 2, composed of 0's and 1's. If Huck could only measure with an accuracy of 1 foot, and the river level varied from a minimum of 20 feet to a maximum of 27 feet, then he could (if he wanted to) use the following values.

River Level	One Possible Binary Representation
20 feet	000
21 feet	001
22 feet	010
23 feet	011
24 feet	100
25 feet	101
26 feet	110
27 feet	111

Table 1

Huck would probably just use the more human-readable feet (or meters, or fathoms, or whatever). But, if he wanted to show off to Tom Sawyer, then binary would probably do the trick.

Sampling a signal at regular intervals, when those samples are done fast enough to not miss things, is how you digitize. In digitization, the mapping of the sampled signal levels to a digital value, as shown in Table 1, is one necessary part. The other is the rate at which you take measurements. The really amazing thing is that the whole analog signal can be exactly reconstructed from just these samples, as long as certain simple conditions are met.

The formal definition tells us that the sampling rate must be at least twice the bandwidth of the bandlimited signal under consideration in order to reconstruct the signal. Therefore, a 3 kHz wide signal must be sampled at least at 6 kHz in order to be able to properly capture it. This minimum sampling rate is called the Nyquist Rate. It is named after Harry Nyquist (**https://en.wikipedia.org/wiki/Harry_Nyquist**), who worked on determining bandwidth requirements for transmitting data.

Nyquist's work provided a solid foundation for Claude Shannon's work. Shannon (https://en.wikipedia.org/wiki/Claude_Shannon) is considered to be the founder of the field of Information Theory. The field of information theory handles questions of error-correcting codes, compression, and determining how much real information can be squeezed into or extracted from a signal.

2016 is the centennial celebration of Shannon's birth. There have been celebrations, documentaries, and many social and technical events to commemorate his anniversary, including a Google doodle! (See **http://www.google.com/doodles/claude-shannons-100th-birthday.**)

Digital representations also include artificially created signals. Instead of sampling existing natural or analog signals, the samples are generated by mathematical algorithms or by shifting binary register values. Digitally synthesized signals serve as radio oscillators. Digital synthesizers can create complex arbitrary waveforms that serve as test inputs for circuits and systems of all sizes.

In photography, the film versus digital debate developed over time (pun intended) with the film crowd responding to early digital sensors by insisting that the resulting digital images did not equal film quality. This was especially true for the first several generations of digital cameras. However, the ease of storing, sharing, copying and editing outweighed the relatively low resolution or problems with dynamic range. And then, the sensors started getting better, and getting better very quickly, and very cheaply. Today's digital cameras take insanely good images at a tiny fraction of the cost of film development. Whatever you gain by developing film has to be worth giving up the convenience, ease, quality, consistency and flexibility of digital photography.

Are there arguments for film photography? Yes, there are. There still are, to this very day! But, digital photography has answered almost all of them. Any remaining application where film is chosen over digital is a question of very exacting (or obscure) requirements, or for the sheer enjoyment of working with a mechano-chemical process. That digital has defeated film is not a completely uncontroversial statement, but one only has to go shopping for cameras or look at the sheer magnitude of published digital photographs to see the effect of digitization on the world of photography.

This same effect has happened in communications. Digital communications are rapidly becoming the standard across the board, getting the lion's share of investment, research and development, and consumer dollars. Digital communications are much easier to secure through cryptographic codes, have superior signal to noise ratios, allow authentication and authorization, can be easily copied, can be easily stored, are much more efficient in terms of bandwidth consumed, can be filtered, and can adapt to link conditions by using different error-correcting codes for different situations. Any of these things is much more difficult to do with an analog signal. So, what's not to love?

Any digital signal is more complex, and therefore more challenging to deal with, than almost any analog signal. Any digital system requires components and techniques that are advanced, potentially cost more money, and are more difficult to select, implement, and troubleshoot. In other words, a more powerful feature set comes at a cost, and that cost is complexity. This is a normal engineering trade-off.

For example, you may have noticed that many digital voice systems sound like crap. If you've used any of the ham radio digital voice systems, or commercial radios like P.25, or even a cellular telephone, you know that the voice quality isn't that great. On the other hand, digital systems for music playback range from pretty good (MP3) to essentially perfect. Voice systems can sound that good, too. The better VoIP telephones and the WhatsApp voice memo system are good examples. What's the difference? It's in how the audio signal is encoded for transmission and then decoded after reception. Codec stands for the combination of the words code and decode. A codec is a hardware and/or software element that does both the coding and decoding functions in a communications system.

Coding is done before transmission or storage, and decoding is done after receiving or retrieving. Coding and decoding have two main purposes. The first purpose of coding is to remove unnecessary redundancy in the samples. This compresses the signal, which increases efficiency. This is often called source coding. The second type of coding adds in the right type of redundancy

and is called channel coding. It may seem strange to first remove information, and then add information back in, but this added redundancy provides resilience and durability to the signal so that it can make it through daunting noise (a terrible radio link), or radiation effects (which is why I hate space), or physical damage (the surface of a CD).

Source coding is like laundry detergent. It removes dirt you don't want. Channel coding is like fabric softener. It puts back in substances that make your clothes perform better in meetings. With the right type of fabric softener, you don't even have to be in the suit to impress.

Crappy codecs are a big problem for digital voice communications because the auditory experience represents the quality of the entire system. Voice quality is in your face and in your ears. Voice is the radio product. Over-compressing voice when it's not necessary results in harsh or unintelligible audio. When compared to a beautiful warm AM transmission, it's hard to justify digital communications when the sound is so much worse.

The reason for this situation with many digital codecs is greed. Greed is not necessarily bad. We want as much as we can get out of a technology or technique, and if the end result is elegant and suitable and affordable, then no harm is done. Digital is no different. With bonus signal-to-noise ratio provided by the physics of digitization and coding, we then have the power to balance at least three factors. We can reduce the size of the antennas, increase the number of users, or deliver that power in the form of higher throughput or higher quality signals to fewer users. For commercial systems, it's obvious which choices result in more revenue: smaller antennas and packing in more users!

As a consequence, codecs are being designed primarily for low bitrates in order to get more users per given bandwidth. Extensive criteria exist for judging codec quality, but intelligibility and harshness are much more subjective determinations than bitrate. Therefore, bitrate ends up being the primary distinguisher between different classes of codecs, and the lower the bitrate, the better. Operators (or users, or customers) are expected to tolerate the lowest possible quality of voice in order for the system to support as many signals as possible. The critique of this practice is that voice is a special case. If the quality of the voice is just simply not as good as analog, then why value a digital ham radio experience over an analog ham radio experience? It may be that the over-compressed voice signal in a digital communications system has zero errors. It may be that data files transmitted over this system are error-free. It may be that all sorts of amazing functions could be implemented. But, if the resulting encoded voice signal is unpleasant to listen to, then the entire system is suspect. As amateurs, we can afford to experiment with systems that don't necessarily have to drive to the absolute tolerable limit of voice encoding. We can afford to try out techniques and use codecs that provide a higher-quality voice experience. If the resulting usage of such systems can be shown to be significantly higher, and the reported satisfaction greater, then this information helps digital design in general.

Digital electronics are complex. What can be surprising is that digital electronics can be so cheap. They are cheap because of the enormous consumer demand for the high performance that digitization provides. Computerization of our world has made it possible to have cheap analog-to-digital converters (the electronic version of our Huck Finn), cheap storage (powerful low-cost memory chips), and cheap computing (Moore's Law). (See **https://en.wikipedia.org/wiki/Moore%27s_law.**)

These three functions are central to the entire digital versus analog argument. You have to be able to convert real-world continuous signals to digital samples. You have to be able to store those samples in some sort of memory device. You have to be able to make decisions about and for those samples. With these three things, you can literally do anything.

What Digital Microwave Communications Provide the Amateur Satellite Service

Microwave bands allow significantly higher bandwidths than any other amateur band. This means a big increase in the number of simultaneous users of any particular payload. Due to higher frequencies, it also means a much smaller antenna is required. Digital can be done on 2 m/70 cm, and a question repeatedly asked is why can't AMSAT simply put up a digital satellite in bands that are already commonly used. The answer is that satellite bandwidths on 2 m and 70 cm are very limited in comparison to microwave bands, and they are very crowded.

The satellite sub-band on VHF is only 200 kHz wide, and existing and planned missions already very heavily utilize it. (See Table 2.) The IARU frequency coordinator warns that all prospective users of the 2 m band must expect to tolerate interference (See **iaru.org/uploads/1/3/0/7/13073366/satellite_frequency_coordination_in_the_two.pdf.**)

In contrast, the 10 GHz band has a 50 MHz allocation for satellites, and has no existing users.

Band	Satellite Band
2 m	200 kHz
70 cm	3 MHz
5 cm	20 MHz each way
3 cm	50 MHz

Table 2

Digital communication allows operators to do things with signals that could not easily be done in analog, such as filter, record, tag, alert and mute particular other signals. Since we're talking about representing everything as data, communications can be voice, voice memo, text, documents, video, video memo, or whatever data type the operator chooses to send. As long as the receiving station knows what to do with it, or can find out how to receive it, the sky literally isn't a limit.

Digital communication allows for the possibility of authenticating and authorizing use of that payload. Each signal can be required to authorize and authenticate before the communications are passed through the satellite.

Successfully and competently implementing authentication and authorization features, if those features are desired or required by the payload management, is a challenge. If you want to work through a satellite, and that satellite requires authentication and/or authorization, then additional steps are needed to get certified through whatever authority is in charge of that payload. This increases complexity for both the ground terminal and payload operators. Doing authentication and authorization wrong is a huge turn-off. Botching it costs time, energy, and goodwill.

The baseline authentication process for Phase 4 is to use the certification process of Logbook of the World. Authentication has to do with identity ("Are you who you say you are?"). Phase 4 Ground's currently proposed authentication process establishes that an operator with a particular claimed call sign can receive mail at the address they gave to their licensing authority. In the U.S.,

that would be the FCC. While this process can be spoofed, it's used to establish that a call sign is attached to a real address, that address was on a license application, and that the licensing authority if necessary can reach the address. This is the baseline functionality that we're including as part of the system approach. If a payload or Groundsat wants more stringent authentication, then it can build that functionality into the system. If it wants less, then it can turn off authentication and run the system the same way every satellite has ever run in the past – with zero authentication and zero authorization. Authentication can be required before system use. Re-authentication can be done on a schedule. Re-authentication can be done based on triggers. The triggers, in turn, may be based on automatically collected data or on other operators' complaints.

Authorization is the question of whether or not the identity you claim in the authentication stage is allowed to use the communications resource or not. You can authenticate, and then not be authorized to do something in particular. Authorization in Phase 4 systems is up to the operator of the payload and can be accomplished by white lists, black lists, or anything in between. The default is open access to anyone who successfully authenticates.

Authentication and authorization are not uncontroversial. They are functions that are easily enabled by digital communications. They are not required by digital communications. One can build a digital system that has no identity management and no limits on who, or when, or how one can access a resource like a satellite. Traditionally, amateur radio communications have been almost exclusively of this type. Your identity is as good as your word, and your signal can't be easily controlled by others. It's much more difficult to discriminate against amateur radio operators, for example, if they can access the same communications resource that you can, without anyone putting them on a list first or controlling whether or not they can be heard. When jammers appear, they are ignored. If you're in the right place, at the right time, with the right gear, you can direction-find, and possibly locate, and possibly report the jammer. When previous authenticated and authorized jammers appear on a digital system that can assert control, then the signal is eliminated by any process available to the control operator.

Accountability, transparency, and consistent standards absolutely are required to avoid any appearance of bias, petty retribution, or discriminatory behavior on the part of the humans controlling the authorization process. It doesn't matter if that process is automatic or manual. Automatic processes can be configured to exclude or promote certain types of users more than others. Re-authorization should be transparent to the operator. Onerous re-authorization requirements, whether put upon the operator or the operator's radio in an effort to exclude or discourage participation, have to be acknowledged as a potential problem for any digital system using authentication and authorization.

Additional Big Challenges for Microwave Digital Satellite Systems

As asserted, the equipment on the ground is more complex than analog gear. That's why the Phase 4 Ground project exists. 5 GHz/10 GHz radios are rare to the point of nonexistent. Radios must be easily built or easily bought (for some definition of "easy"), otherwise the "Five and Dime" satellites and Groundsats (terrestrial deployments of the system) simply won't be fully utilized.

Microwave-band analog transponders may be accessible with radios that are already in circulation or are less difficult to get up and running. That's a fact of technology that is not in dispute.

The goal of Phase 4 Ground is dramatically to increase the number of digital microwave experimenters, operators, and providers of commercial gear, in order to provide radios for all sorts of Five and Dime satellite and terrestrial operations. The end goal is for someone to be able to purchase or build a digital microwave radio system and put it on the air with minimal difficulty or configuration. Buying a system may be as easy as going into your local ham radio store or ordering off the web. Building up a system may be as simple as "buy SDR brand so-and-so, build this filter and/or this transverter, connect it this way, use these web-apps, then download this GNU Radio flow-graph, and then press play".

We firmly believe that the advantages of digital microwave radios outweigh any advantages that analog microwave radios might have. We believe it's well worth the additional complexity to enable advanced communications functionality. Advancing the radio art is what we're supposed to be doing as part of the amateur service. Adding expertise in digital communications certainly qualifies, and is well worth the time and energy required. Education and the opportunity to design advanced digital circuits are primary goals of Phase 4 Ground.

Second is the expense. Satellites are expensive. Many things can go wrong with a digital satellite payload. Aside from failures due to the environment, and despite the fact that software can be updated from the ground for certain types of computers, increased risk and increased cost result from the nature of digital electronics. This is a risk that has been and will continue to be confronted by all the teams working on the various digital payload projects. Mitigating factors include using radiation-hardened electronics, designing in the right types of redundancy, having quality engineering design and review, and engaging diverse teams that can bring a variety of backgrounds and viewpoints to a project. Things get missed when everyone thinks alike.

Third is legally being able to discuss payload engineering. ITAR and EAR still greatly affect AMSAT-NA work. Phase 4 Ground separated itself from the Phase 4B payload team (and any other payload team) in order to avoid unnecessary restrictions that would greatly hinder our ability to recruit, document, and publish ground terminal designs, software, and documents. This decision has made it much easier to get things done, but comes at the cost of having to take great care in communicating back and forth with the various digital payload teams.

At this point, various microwave digital payload projects include at least Phase 4A, Phase 4B, Cube Quest Challenge, Phase 3E, Terrestrial Groundsats, and several potential digital LEO projects. This is a great start!

Current ongoing needs include volunteers unafraid to code for general purpose processors (GPPs), digital signal processors (DSPs), and field programmable gate arrays (FPGAs). Volunteers are needed for radio frequency circuits, enclosures, user interfaces, web apps that control the processors that are in these radios, protocol development, forward error correcting codes, and many other fields! If you've wanted to get involved with digital processing, design, or communications, then this is a very worthwhile project with a wide variety of moving parts. The protocol for the downlink is DVB-S2 (and DVB-S2X) for satellite links and DVB-T2 for terrestrial. This extremely popular standard is available for download from the DVB project at **https://www.dvb.org/.**

Phase 4 Ground serves any payload project that complies with the proposed "Five and Dime" air interface. Our project documents can be found on github at **https://github.com/phase4ground.**

If you want to contribute to Phase 4 Ground then join the mailing list by applying at **http://www.amsat.org/?page_id=1121.**

The Phase 4 Ground list is open to all who want to contribute to the project. If you are interested in working on a payload, then use the same form, just specify payload engineering instead of ground terminal work. Payload teams need you, too! One in particular is Phase 4B.

Phase 4B is a PACSAT Payload For The Entire Sector of the Earth Containing the United States

This major initiative has been undertaken by Virginia Tech. AMSAT is a crucial partner. The goal is to produce a rideshare payload suitable for a geosynchronous satellite (or a geostationary satellite if you have one laying around). It is an example of the five and dime (5 GHz and 10 GHz bands) strategy.

Michelle's team has pushed forward with a complete air interface specification using a well known and widely available standard: DVB-S2X. Virginia Tech, Hume Center, has accepted the conclusions and analysis that have been done to produce the specification for the waveforms for the Phase 4B payload.

We have received a generous donation by Rincon Research Corporation of Tuscon, AZ. Rincon was founded by Mike Parker, KT7D. Through his generosity, we now have the complete software defined radio needed for our mission. It was designed by Rincon with a CubeSat form factor but don't let the size fool you. It is likely the most capable CubeSat communications payload ever talked about publicly. Rincon Research is a top notch research and development company doing lots of complex signal processing for various places but mostly for the U.S. Government.

The Rincon AstroSDR is based on the Zynq 7045 system on a chip (SoC). This chip is an ARM running Linux directly connected to an FPGA core in the Virtex 7 family from Xilinx. This powerful combination is married to a very capable RFIC which is a two channel transceiver capable of tuning low VHF through 6 GHz with reasonable performance. Please view the engineering model in Figures 1 and 2 below.

We can package the AstroSDR for use in our transponder payload. That is exactly what we proposed to our host for our rideshare on a spacecraft being built by Millennium Space Systems, Inc.

One of the things we know we need to do is to implement the forward error correction coding scheme. As described above, this type of coding corrects the inevitable bit errors that occur when you are attempting to receive a weak digital signal way out in space. As such, we are happy to report that Virginia Tech, Ettus Research, AHA Incorporated, and AMSAT working on the ground terminal have teamed up with financial support donated to us from Ettus.

Ettus Research is a division of National Instruments and responsible for the USRP. AHA is a company well known for doing high quality signal processing code on FPGAs. The goal for this collaboration is to implement a form of Forward Error Correction known as Low Density Parity Check (LDPC) which is extremely powerful, free from all intellectual property protections and available in FPGA firmware code from AHA.

AHA, Inc is based in Moscow, Idaho and a former Virginia Tech Hokie, Juan Deaton, is responsible for their involvement in helping us with this very difficult coding. A small team of Virginia Tech people and possibly AMSAT people will go to the AHA facility. Their goal will be to port the code to the AstroSDR and the USRP using the Ettus Framework for making FPGA code much easier to use in signal processing code by GnuRadio developers as part of their normal "flowgraph" programming.

There remains a lot to do to make this payload fly. But we are happy to report that the entire mission has been approved by the U.S. government and the spacecraft builder, and we are entertaining contract negotiations with the U.S. government representative which is managing the contract out at NASA Ames in California.

Payload preliminary design review (PDR) and other materials are online at VT. Please visit the Phase4B web site at VT which is http://www.hume.vt.edu/geo and consider contributing to the effort because we must raise lots of money to fly but we need a much smaller amount to finish the payload. AMSAT's intention is to use all of what is developed for the Phase 4B mission in as many different projects as it can going forward. The full power of SDR is finally available for complex, reconfigurable operation in space from LEO to GEO.

All donations made to the Phase 4B project using the URL provided on the web site above are going to Virginia Tech. If you are in the U.S. and pay federal taxes, it is a tax deductible gift. Finally, you will see in the report for the PDR that some minor things have been redacted. This is the cost of doing business in an ITAR world.

Figure 1 — AstroSDR from Rincon Research next to an N connector (side 1).

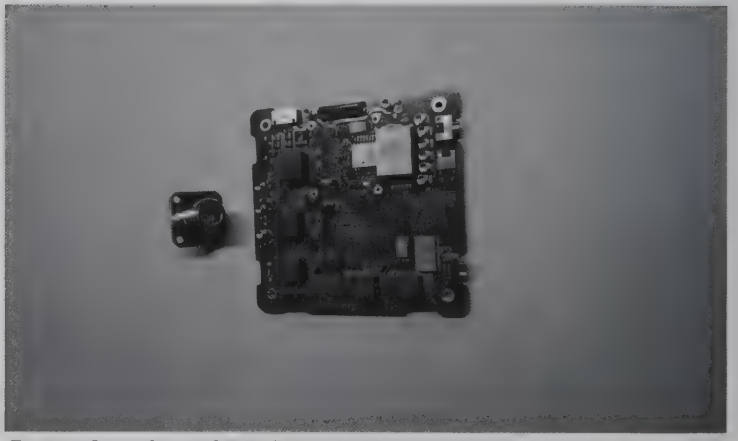


Figure 2 — AstroSDR flip side next to an N connector.

QRV from Curaçao, PJ2

Michael Lipp, HB9WDF
Translation by Bernhard Jatzeck, VA6BMJ
Assistant Editor

My diving holiday on Curaçao had been planned for quite a while. The decision also to indulge in my amateur radio hobby while on the island occurred to me only a couple of days before departure.

The decision resulted from our realization, during the packing of our underwater equipment, that we wouldn't reach our baggage limit. My amateur radio heart skipped, naturally, out of joy, as I saw that the allowed baggage limit was only a third filled.

Curaçao belongs to the "ABC islands" (Aruba, Bonaire, Curaçao) in the south Caribbean and lies about 60 km north of Venezuela in South America. Curaçao is so ideally situated that I decided to be QRV on HF as well as satellites.

SO-50's footprint indicated to me that QSOs from Brazil to Canada should be possible. Shortly before leaving, I tested my home-brew dual-band antenna. With my ICOM IC-92 and Yaesu VX-8 hand-held transceivers, my satellite equipment was complete and, with this hardware, I could operate QRV over SO-50 and AO-85.

My Travel-ready Satellite Antenna

The antenna was built so that it could fit into a travel bag. I based its construction on the design by DK7ZB.

The antenna has 4 elements on 2 m and 7 elements on 70 cm. The radiating elements consist of extended dipoles that have a lambda-1/4-match for 2 m and a lambda-3/4-match for 70 cm. These adjustments are physically identical in construction.

The boom halves are constructed from PVC electrical conduit held together with a standard sleeve. The antenna's passive elements are held together with plastic clamps that are directly attached to the boom.

I modified the 2 m band elements in order to pack them. An antenna element for that band is approximately one metre long, and a suitcase or travel bag is usually about 70 - 80 cm (roughly 27-32 inches).

The mid-section hardware allowed the dipole to be disassembled and, therefore, didn't pose any problems for packing.

The problem with my original design was that the reflector and director elements were each one continuous piece. Those couldn't fit into my bag. My solution was to cut those parts into sections so that they could fit.

The next challenge was how to attach those parts to the boom. To solve that, I used some small aluminium sleeves with an inner diameter large enough so that the ends of the elements could snugly fit in. I mounted those sleeves on a tube clamp, which was then fastened to the boom. All I had to do after that was to fasten the outer segments of the elements in place with insulating tape.

Murphy Was a Guest at the First Attempt

Drew, KO4MA, and I had agreed on a schedule. I decided to use the IC-92 for the uplink and the VX-8 for downlink and my tests just before the pass showed that everything was in order.

The sun was already setting over Curaçao when SO-50 came up over the horizon for a 12° maximum elevation. Drew already was waiting for me, but my transmissions were cut off, and I was also receiving some strange interference.

I paid the price for a short preparation time. That attempted QSO failed despite all efforts. Disappointed and frustrated, I turned around and went back into the apartment.

My YL showed me her fantastic underwater photos that she took during our dive. Really, they were good, but at that moment I had no enthusiasm. My inability to QRV over satellite frustrated me. I had to remedy that, so my resolve was roused.

Searching for the Malfunction

I received a suggestion from Drew, KO4MA, that I should check the sub-audio settings. He was referring to my uplinks being cut off after a second and suggested that I didn't have the sub-audio frequency set properly.

Now, I must admit that even though I had checked the functionality of the transmitter, I did not check to see if I had properly set the sub-audio.

I opened the sub-audio squelch on the VX-8 and transmitted with the IC-92. Indeed--no sound from the rig. Only the S-meter bars appeared. I had, indeed, set the subaudio frequency properly but incorrectly set the encoders. The IC-92 was set to "Tone" instead of "TQSL". After I changed that, the receiver whistled loudly due to audio feedback.

I solved the uplink problem, but not the downlink interference that I heard during the QSOs. That problem was quite stubborn, and a lack of measuring equipment and tools prevented a quick solution. In the end, it was

Departure from HB9. On the left is the diving equipment, on the right is the amateur radio gear.

split ends on the adjustment bar, which were nearly invisible, that caused a short circuit. In the style of McGyver, I solved the problem with a pocket knife.

To test this, I used Radio Curaçao on FM as the transmitter. The results showed that the problem indeed was solved. I quickly informed Drew and arranged for a new schedule.

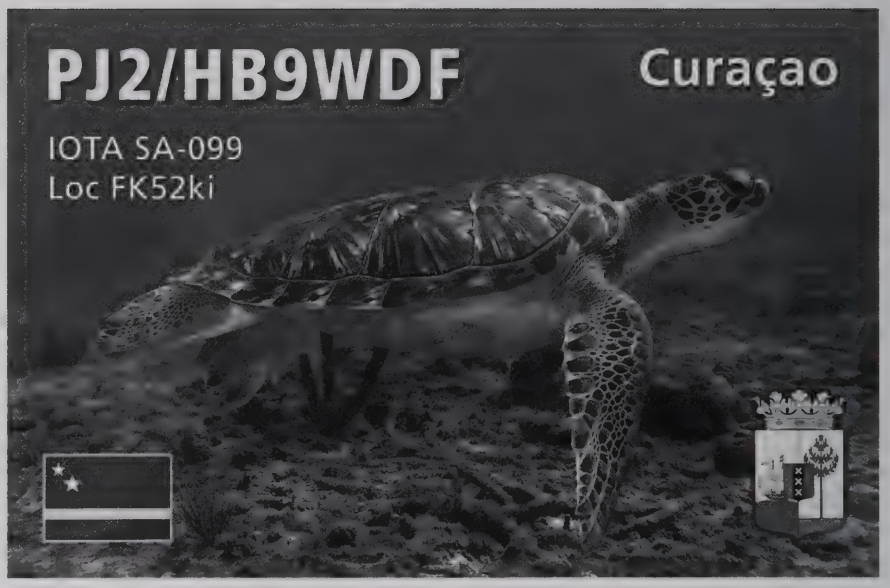
And It Works

This time, SO-50 flew higher than 50° over the horizon. That QSO with KO4MA worked the first time. And, thanks to a Twitter posting, in which Drew wrote about my activities, I got a small pile-up as well.

The next day, I read a message on the AMSAT-NA Facebook group from James Lea: "KM4IPF is heading out to work the 2335Z SO-50 pass." I answered and wrote that I would attempt to work it as PJ2/HB9WDF QRV.

I wasn't aware at the time of who KM4IPF was, though I assumed it would be James. SO-50 appeared on the southwestern horizon and I called CQ. It didn't take long before the first QSO was in the log.

Suddenly, a young female voice called me: "PJ2/HB9WDF, this is KM4IPF, over." I wasn't prepared for that and was quite surprised. I had a short QSO with her. KM4IPF seemed to me to be a well-experienced radio amateur, as her operating was impeccable.



The QSL card. For many, it's confirmation of a new country.

Following that contact, I logged more North American stations.

After that QSO, I searched on the Internet and found out who KM4IPF was. Hope is 9 years old and had her license for only a few months. I was astonished. During that pass, I also had a QSO with Hope's father, James Lea, WX4TV. For both of them, PJ2 was a new DX entity, which James wrote in an e-mail to me and which, naturally, pleased me.

In the following days, I received numerous e-mails with schedule requests, so I became aware of what my activities on Curaçao had started. Unfortunately, I couldn't answer everyone's calls as, on the FM transponder, pile-ups are hard to manage. Although the operations in North America were quite disciplined, and I could work several stations, it appeared that, now and then, some QSOs were interrupted by a CQ call.

DX Paradise for North America

I was astonished that, during my stay in Curaçao, I wasn't the only DX station on satellite. Chris, 9Y4D, was QRV on Tobago, and we were joined by Burt, FG8OJ, on Guadeloupe and XE1MEX from Mexico. It was truly paradise for radio amateurs in North America.

Unfortunately, it also meant that the number of QSOs during a pass was very modest. We tried, as far as possible, to watch out for each other so that each DX station had its turn. Once in a while, though, it became chaotic as some stations became impatient. That's understandable on an FM transponder for which the DX window lasts only a few minutes.

Landing approach to Curaçao from the direction of Westpunt. The contest station PJ2T is located in the inlet area.

QSO at the Horizon

The QSO I had with Fernando, NP4JV, will remain especially memorable. He lives in Nogales, Arizona. At the time of our QSO, SO-50 was, for him, barely over the horizon at only 2°, and it wasn't much different for me.

The contact was flawless, and we worked each other with the identical portable hardware and 5 W output power. Fernando sent me an e-mail after the QSO and

The fully-assembled satellite antenna awaits use.

It was possible to easily operate on passes up to 25°.

described his experience and impressions of the contact. He was quite excited that the contact was successful.

It was quite surprising how many YLs and OMs contacted me by e-mail after our QSOs. For some, they were concerned only with whether the QSO was actually logged. Others wrote me that the contact by satellite with the Caribbean was a great experience and that they were pleased about the new DX entity and grid square. Some even sent me descriptions of their stations. From that, I found out how surprisingly many North American radio amateurs were QRV with portable stations. Actually, I really didn't need a logbook. Every station with which I had a satellite contact sent me an e-mail afterward.

Murphy Wanted to Know

The sleeves for the 2 m elements were fastened to the terminal clamps with two-part adhesive. After a few days of intense sunlight and, perhaps also due to the salty air, the bonds became soft and the elements fell off. Luckily, I had packed some fabric tape and the damage was temporarily repaired.

For the last pass, I connected my rigs to their chargers. After half an hour, when I went to check on their status, I saw that the IC-92's charge indicator wasn't being displayed. My IC-92 was one of the first generation models, so the power supplies handled only 220 V. On Curaçao, however, it's 110 V. "Murphy still wanted to tell me something at the last minute," I thought.

With the remaining charge I still managed my last QSOs. After that, I dismantled the antenna and stowed it in my luggage.

Conclusion

I had a lot of fun with the satellite activities in Curaçao. The numerous feedback comments and experiences were worth the effort. However, for my future home brewing, I'll need to spend more time on the quality, so as not to give Murphy another chance.

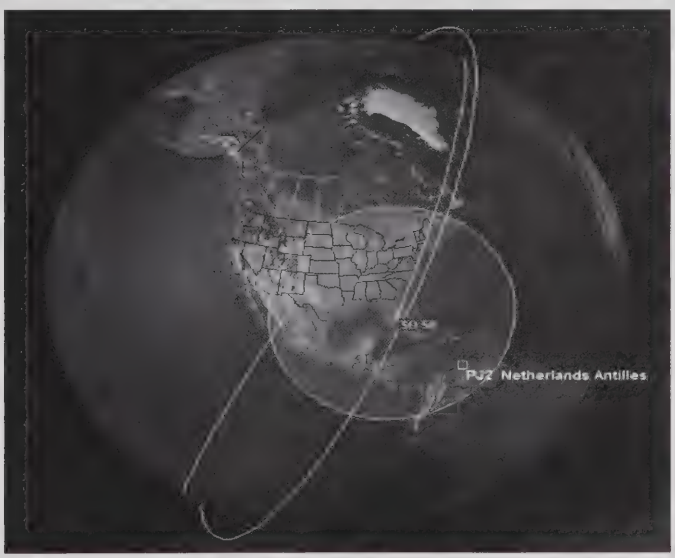
The expedition showed me where the limits are for a simple homebrew project, the type that one would like to quickly put together in the evening after quitting time. A bit more time and patience are always good. Also, the type of materials to be used should be carefully considered.

FM satellites are really easy to work. When there's less activity on the bird, it's particularly good. In pile-ups during a DX-pedition, a single-channel transponder can be counterproductive. W5PFG recorded the downlink for a complete SO-50 pass and it's available to the public on Soundcloud. From that, I could tell that many more stations called than I personally heard on Curaçao.

For pile-ups, SSB satellites would be better. Drew, KO4MA, presented at the AMSAT-UK Colloquium 2015 how one can be portable QRV over FO-29 with two FT-817s and an Arrow antenna. That's a good idea and a possibility for my future activities.

Another objective for the future goes beyond LEO satellites. For about 15 years, I put in a lot of time in preparing a portable station for AO-40. With an eye on P4A, I should reactivate my old ideas and bring that project back to life.

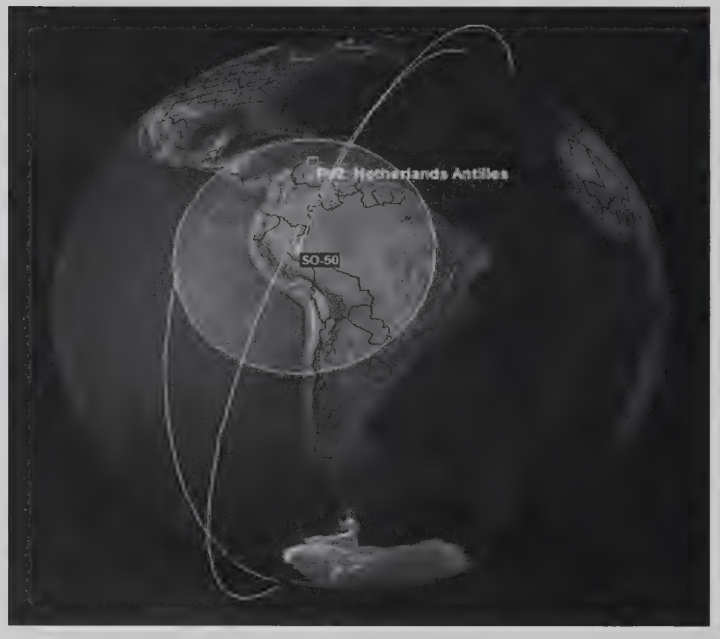
[Editor's note: a previous version of this article appeared in the AMSAT-DL Journal.]



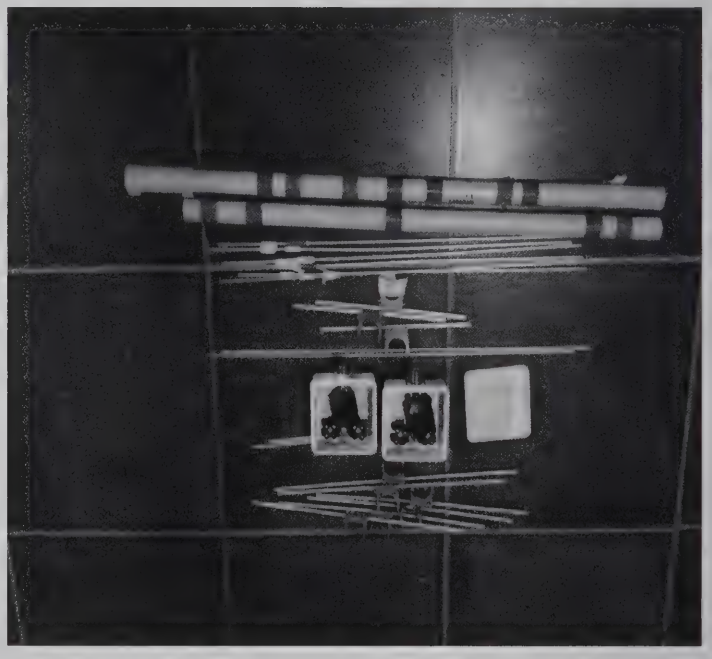
There were large pileups over North America. Note how the footprint just touches the state of Arizona, from where NP4JV could operate over SO-50 with a 1.5° elevation.

Mounting detail for 2 metre element mid-section.

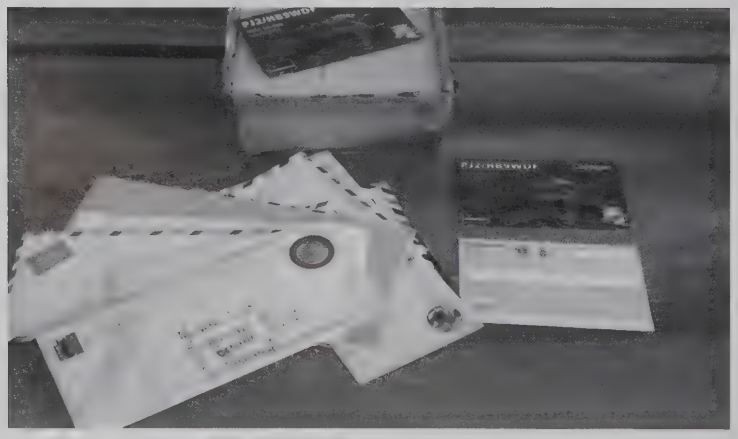
2 metre element fully assembled.



The topography allowed only southwestern passes for South America, with few contacts made.



The disassembled antenna easily fits in any travel bag.



Barely back home and already there was work to do. Surprisingly, lots of QSLs had been sent directly.

Protecting Satellites and Ground Stations from EMP and CME

Joe Kornowski, KB6IGK
Editor

A catastrophic electromagnetic pulse (EMP) or severe solar coronal mass ejection event (CME) could put an end to amateur radio satellite operation as we know it, among other things. Even less severe EMP and CME events can cause significant damage that might require days, weeks or even months to repair. The challenge facing amateur radio satellite operators is how best to protect our radio stations and satellites from significant damage or loss.

The concern for satellite operators is less about taking an extended hiatus from our amateur radio satellite hobby than about the key role amateur radio plays in disaster-related auxiliary communications. This role is the mission focus of the Amateur Radio Emergency Service® (ARES), Radio Amateur Civil Emergency Service (RACES), Military Auxiliary Radio System (MARS), and the Salvation Army Team Emergency Radio Network (SATERN). Even the annual ARRL-sponsored Field Day event states, as one of its objectives, "developing skills to meet the challenges of emergency preparedness."[1]

Amateur radio's emergency preparedness and disaster-related assistance activities historically have been conducted only through terrestrial communications. That has begun to change. The Amateur Radio Satellite Corporation (AMSAT) annually conducts its own amateur radio satellite field day, held concurrently with the ARRL version. (Read results of the most recent AMSAT Field Day in this issue.) Certificates are awarded to the first place emergency power/portable station, and the "second and third place emergency operation, in addition to the first place home station running on emergency power."[2] Clearly, the emphasis of satellite field day is on using emergency power or operating portable.

Additionally, a digital microwave geosynchronous (GEO) amateur radio satellite service system is planned through a partnership between VirginiaTech, AMSAT, and Millennium Space Systems. Referred to as "Phase 4," one of the GEO satellite's intended applications is emergency communications. According to Bob McGwier, N4HY, Director of Research at the Hume Center for National Security and Technology at Virginia Tech, FEMA has stated, "If you build it, we will use it," and indicated that it would request the ARRL to use 100 units for ARES go-kits.[3]

While we clearly have no control over either the magnitude or timing of an EMP or CME event, we nevertheless can be prepared by implementing various strategies, both in space and on the ground, that can protect equipment or otherwise get systems back online and on the air as quickly as possible. Government and industry shoulder primary responsibility for protecting the electrical power grid and other vital infrastructures at the national, regional and local level. As with most indiscriminate disasters, however, the ultimate responsibility for protecting non-governmental individual spacecraft, stations, networks and systems against EMP and CME damage falls on the owner and operator – us.

In order to determine what mitigation measures might be most effective in a given scenario, we first need to understand how EMP and CME work, the different characteristics of the events we likely would face, the nature of the specific threat, and the probabilities of occurrence.

EMP

EMP and CME are quite different in how each affects the power distribution system and electronics. EMP can severely affect both electronics and the power distribution system.

Man-made Versus Natural

Much has been written about the concept of a nuclear-based EMP attack. Briefly, old Cold War enemies (i.e., China and Russia), or rogue states like North Korea and Iran, or sophisticated terrorist organizations would detonate one or more nuclear weapons high above the U.S. This would interact with the Earth's atmosphere, ionosphere, and magnetic field to produce an EMP that radiates downward on Earth, creating electrical currents and magnetic fields that could damage electrical power systems, telecommunications systems and electronic devices. The resulting effects could prove catastrophic.[4]

In his excellent QST article, "Electromagnetic Pulse and its Implications for EmComm," Bob Schroeder, N2HX, wrote that during an EMP attack, "the resulting electromagnetic field ... is produced by the recoil of the electrons." As he explains, "This field propagates through space and induces a current into any metal object in its path. This can include spacecraft, aircraft or any metal conductors on, above or even below the ground."[5] (See Figure 1.) Strategically placed, a detonation producing an EMP burst could affect the entire continental U.S. (See Figure 2.)

Another kind of EMP, which could be either more or much less devastating, could be produced by a CME, as discussed below.

Dual Threat

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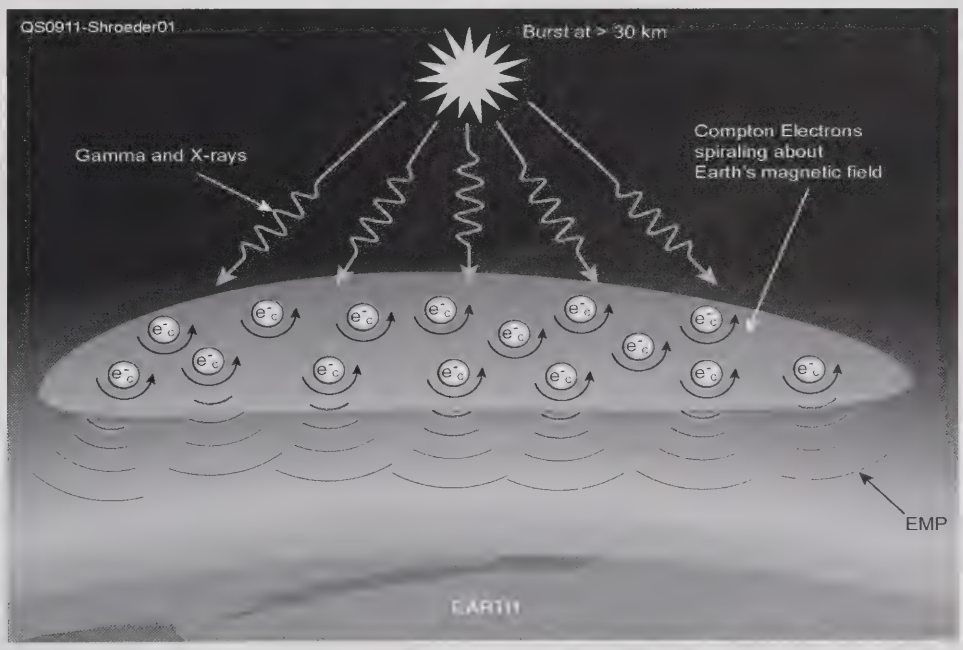

Figure 1 [courtesy of *QST*].

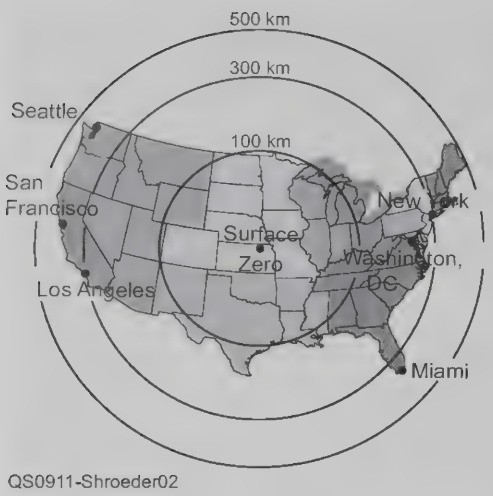

Figure 2 [courtesy of *QST*].

of the 2010 Defense Threat Reduction Agency (DTRA) report, Collateral Damage to Satellites from an EMP Attack states, "Use of a high altitude nuclear detonation as an electromagnetic pulse (EMP) attack on a terrestrial target may generate both immediate and long-term radiation threats to Earth-orbiting satellites."[6]

As we all know, the spacecraft is only half of the communications link. The DTRA's report explains that, "Ground stations are at risk from EMP effects, and the medium through which a satellite's radio signals propagate can also be disturbed for as long as several hours due to ionization of the atmosphere by the nuclear burst."[7]

1. Easy Sats, Easily Reached

According to the DTRA, low-Earth orbit (LEO) satellites "would be most affected by a high altitude EMP burst."[8] The reason is that typical altitudes for detonation of nuclear warheads creating high-altitude EMP are 40-400 kilometers. That could include a number of amateur radio satellites and the International Space Station, depending on the positions and altitudes of those spacecraft relative to the detonation.

Unlike with LEO satellites, however, the DTRA states that, "the large distance between a detonation for an EMP attack and a satellite in MEO [Medium Earth Orbit] or GEO [Geostationary Equatorial Orbit] makes the probability of damage to them very low."[9]

2. Sizzling Stations

Schroeder writes that, given the high-frequency pulse of nuclear-generated EMPs, "we can expect that conductors as short as 1/4 wavelength at, say 144 MHz, would make good EMP collectors." That would include pieces of wire, poles, antennas, rods, and pipe, among other metal objects that approximate 19 inches in length.[10]

These wires or other metal objects pick up the EMP pulse and transfer or couple it to connected or nearby susceptible devices.

Probability

While the DTRA has approximated the relative probability of damage to satellites in LEO, MEO or GEO resulting from EMP attack, no U.S. government agency appears to have stated publicly its assessment of the probability of an EMP attack. This is not surprising given the subjective, speculative and highly fluid nature of the kinds of circumstances that would result in an EMP attack.

Mitigation

When it comes to protecting LEO satellites from EMP, DTRA concluded, "radiation hardening of satellite components will likely prolong LEO satellite survival times measurably. Outstanding questions revolve around relative costs versus benefits to be derived from an investment in hardening technology."[11] In practical terms, non-profit organizations and academic institutions that have begun to launch relatively simple and inexpensive LEO CubeSats (such as AMSAT and most universities) likely will find hardening technologies cost-prohibitive.

Alternative strategies include making it up in volume, which is to say that enough redundant LEO satellites spaced far enough apart could avoid a total, or perhaps even significant, loss of LEO amateur radio satellites. Another strategy simply would call for making a priority the launch of GEO and HEO satellites that could more likely continue to operate beyond the reach of a nuclear-based EMP.

When it comes to protecting ground stations, EMP mitigation is more difficult. Early tests with solid-state amateur equipment indicated very little damage as long as no long wires were attached. The key is having sufficient hardware protected from the EMP pulse so that recovery is possible.

Bob Schroeder suggests using a combination of shielding, filtering and surge protection to provide the most effective protection.[12] Surge protection can be used to short antenna cabling to ground in the event of a lightning strike. The problem is that EMP has a much faster rise time than lightning so that the kind of long wires used for lightning protection will have much too high an impedance for EMP. (See Figure 3.) Given that, Schroeder suggests, "The most effective EMP surge protectors are mounted as a part of penetrations through shielded boundaries with direct connection to the shield at the point of entry."

Schroeder also concedes that simply disconnecting sensitive equipment, though effective, may not be a viable option for

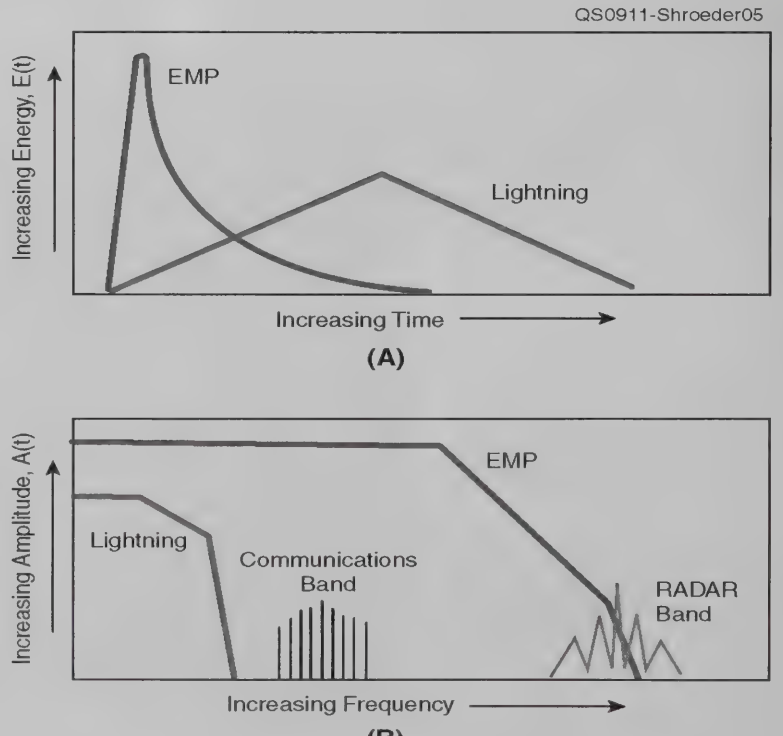

Figure 3 [courtesy of *QST*].

an operating station. This is especially true for nuclear-generated EMP because the burst likely would happen with no advance warning, unlike most thunderstorms and potentially CMEs (as discussed further below). Accordingly, maintaining backup/redundant equipment appears to provide a more realistic option.

Carrying the idea of spare equipment further, the combination of a Faraday cage large enough to accommodate fixed station equipment, as well as a go-kit or "bug-out bag" with portable equipment, could offer some appealing benefits. Such a solution, first, would provide the flexibility of using either fixed or portable radio operation and, second, conveniently centralize backup equipment in one location along with other needed survival gear and supplies.

The Faraday cage – a large steel trash can, for example – could contain, in addition to radios, a portable power pack, such as the P3Solar Dynamo Plus used by the U.S. military, to provide a lightweight 25 W foldable solar panel that can power electronic devices including smartphones, notebook computers, and tablets. Even smaller solar chargers, like the 6.5 W EnerPlex Kickr IV, can recharge AA batteries for dual-band HTs, phones, weather and GMRS/FRS/MURS radios, GPS devices and LED flashlights like the Fenix LD12 or UltraFire. And before anyone suggests that cell phones would be useless if the power grid and cellular networks get knocked out, consider adding a set of goTennas to create your own off-grid network for text and GPS through your smartphone.

CME

CMEs are naturally occurring events in which the Sun ejects huge plumes of ionized plasma. Such plumes are many times larger than the Earth and are entwined with magnetic fields, travelling one million miles per hour or more. These fields disrupt the solar wind flow, producing disturbances that strike the Earth. Sometimes the results are disastrous.

The frequency of CMEs can vary with the sunspot cycle. During solar minimum, we may observe one CME a week, while around solar maximum the average is 2 to 3 CMEs daily.

Threat

While these frequent CMEs typically can be inconvenient or perhaps wreak havoc temporarily on telecommunications, including radio communications and portions of the power grid, they are less of a concern than the larger, more energetic variety.

In his book, *Apocalypse Unknown: The Struggle to Protect America from an Electromagnetic Pulse Catastrophe*, Dr. Peter Vincent Pry, Executive Director of the Task Force on National and Homeland Security and Director of the U.S. Nuclear Strategy Forum, writes, "If a particularly energetic one of these solar torpedoes hits the Earth, it would shudder the protective magnetosphere that surrounds our planet, and generate a powerful electromagnetic pulse (EMP) that could collapse electric power grids everywhere, plunging every modern nation into a protracted blackout. Perhaps permanently."[13]

According to NASA, the EMP blast can accelerate protons and electrons to electrify satellites and damage their electronics.

Probability

Dr. Pry suggests that a particularly large and fast CME, a solar super-storm, could be devastating:

> *The Earth is overdue for a solar super-storm that could inflict a global catastrophe. The last such super-storm, called the Carrington Event, happened in 1859. It caused fires in telegraph stations and destroyed the newly laid trans-Atlantic telegraph cable. But in those horse and buggy days civilization did not depend upon electricity. The Congressional EMP Commission estimated that a Carrington Event class geomagnetic super-storm probably occurs every century. Arithmetic suggests that, as of this writing in December 2012, as we enter another solar maximum, we may be overdue for another Carrington Event.*[14]

Pete Riley, who has studied the solar corona and inner heliosphere for about 20 years, believes that "the probability of another Carrington event ... occurring within the next decade is 12%."[15] In fact, on July 23, 2012, a powerful CME flew out from the Sun at an initial speed of 2500 ± 500 km/s, fortunately directed away from Earth. However, analysis shows that if that solar storm – as large or larger than the 1859 Carrington event – had occurred in mid-July, it would have directly targeted Earth, with devastating effect.[16]

Mitigation

In preparing for a CME, one advantage we might have over a nuclear-based EMP event is some advance warning. NOAA's Space Weather Prediction Center (SWPC) and NASA monitor solar activity, issuing warnings about CMEs and other changes in the solar wind.

During the 2012 solar super-storm, one of NASA's satellites, the Solar Terrestrial Relations Observatory (STEREO-A) was in the path of the CME, and STEREO's sensors detected the CME's arrival about 19 hours after its initial detection.

With monitoring tools such as SWPC's 3-day forecast, if a massive CME were spotted, utilities might have adequate time to take protective measures, like disconnecting transformers. Satellite owners/operators potentially could decrease the likelihood of damage by switching some satellites into safe mode.[17]

Another relative advantage to the individual amateur radio satellite operator is that CMEs are low-frequency phenomena. This means that CME is unlikely to affect electronic equipment directly. Small equipment – full-duplex transceivers, HTs, PCs, power supplies, pre-amps, antennas and related equipment – are much less at risk, so long as you can unplug them in time.

Then again, in a rare super-storm, disconnecting equipment might not be completely effective. The Congressional EMP Commission discovered that the Sun produces a great geomagnetic storm every hundred years or so that can generate EMP effects – referred to a Geo-Magnetic Disturbance (GMD) – similar to a multi-megaton nuclear detonation.[18] Unlike the fast electromagnetic shockwaves of nuclear EMPs, these GMDs are relatively slow, though still powerful, and perhaps would not cause the same damage to personal equipment as nuclear-created EMPs.

A combination of whole-house and individual surge arresters that limit peak AC voltages may be the best protection against a severe CME. Disconnecting the house, or other station location, from the utility grid before an event and running on a backup generator would provide effective protection. If the surge arresters function correctly, the house wiring would not collect sufficient energy to cause any problems.

Alternatively, the station-in-a-cage solution seems like a simpler approach, either alone or in conjunction with appropriate surge protection and shielding.

Most people will have higher priorities when an EMP or major CME event happens than getting their radios working. For amateur

radio operators with satellite capability, however, fulfilling the mission of emergency/auxiliary radio communications (i.e., "when all else fails"), with their special skills and experience, might be reason enough to take some relatively simple measures now to protect their ability to get back on the air when the bad day arrives.

Notes

[1] Rule 2, ARRL Field Day 2016 Rules (ARRL: 2016).
[2] B. Paige, "AMSAT Field Day 2016," *The AMSAT Journal*, March/April 2016, p. 22.
[3] J. Kornowski, "Dateline Dayton – Notes from Hamvention 2016," *The AMSAT Journal*, May/June 2016, p. 8.
[4] D. Foster, et al., "Volume 1: Executive Report," *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack*, 2004, p. 1 [Commission Report].
[5] H. R. Schroeder, "Electromagnetic Pulse and Its Implications for EmComm," *QST*, Nov. 2009, p. 38 [Schroeder].
[6] E. Conrad, et al., *Collateral Damage to Satellites from an EMP Attack* (Defense Threat Reduction Agency: 2010), p. 1 [DTRA Report].
[7] DTRA Report, p. 1.
[8] DTRA Report, p. 5.
[9] Commission Report, p. 111.
[10] Schroeder, p. 39.
[11] DTRA Report, p. 134.
[12] Schroeder, p. 40.
[13] P. Pry, *Apocalypse Unknown: The Struggle to Protect America from an Electromagnetic Pulse Catastrophe* (2013) p. 3 [Pry].
[14] Pry, p. 3.
[15] P. Riley, "On the Probability of Occurrence of Extreme Space Weather Events," *Space Weather, Vol. 10* (American Geophysical Union: 2012), p. 1 [Riley].
[16] D. Baker, "A Major Solar Eruptive Event in July 2012: Defining Extreme Space Weather Scenarios," *Space Weather, Vol. 11* (American Geophysical Union: 2013) pp. 585-586, 590.
[17] J. Stromberg, "What Damage Could be Caused by a Massive Solar Storm?," *Smithsonion.com*, 2013.
[18] Pry, p. 15.

Aboard the Queen Mary – W6RO on AO-7

by Patrick Stoddard, WD9EWK/VA7EWK
Director, Field Operations
wd9ewk@amsat.org

On March 4, 2016, I was in southern California to give a presentation and demonstration of satellite operating for the Associated Radio Amateurs of Long Beach (ARALB). The Queen Mary's amateur radio station, W6RO, is operated by ARALB, and the club had invited me to visit the ship's wireless station. So, the next day, while sightseeing with Endaf Buckley, KG6FIY, around Los Angeles, we headed to the Queen Mary in Long Beach harbor.

W6RO has several operating positions, covering bands from HF through 70 cm. One of the stations is set up for satellite operating, with a Yaesu FT-847, Yaesu az/el antenna rotator, and long-boom Yagis for 2 m and 70 cm (Figure 1). The W6RO satellite station was originally set up in the days of AO-13, and has not been used much in recent years. While looking around the station, W6RO's station manager, David Akins, N6HHR, asked if I wanted to try operating the satellite station. I discovered

Figure 1 — W6RO satellite antenna [Patrick Stoddard, WD9EWK, all photos].

Figure 2 — AO-7 pass prediction.

Figure 3 — W6RO station manager, David Akins, N6HHR.

there was an AO-7 pass about 30 minutes away (2232 UTC), and David gave me the FT-847 manual. Never having used an FT-847 to work satellites, I began reading the manual and looking at the radio and rotator controller in the hopes of making contacts during the AO-7 pass.

Using the AmsatDroid Free tracking app on my Nexus 5 mobile phone (Figure 2), I saw that AO-7 would pass very high over the ship, up to a maximum elevation of 70 degrees. I posted a message to the AMSAT-BB list and tweeted that I would be on the AO-7 pass at 2232 UTC. I was ready to go.

The FT-847 gave me one challenge right away. The Sub-Tune knob would only tune downward, no matter which way I turned the knob. By flipping the VFOs around, I was able to line myself up and start CQing. I made one QSO right away, with Dave, KG5CCI. My "audience" - KG6FIY and N6HHR - were happy to hear W6RO make a satellite QSO for the first time in several years.

The Sub-Tune knob gave me more fits, but near the end of the AO-7 pass I logged two more QSOs. I worked Larry, WA6DIR, north of the ship near Los Angeles, followed by Bryan, KL7CN/W6, near Sacramento in northern California. Even with the small number of QSOs, this brief activation of W6RO on AO-7 was deemed a success.

Thanks to KG6FIY, two video clips of my W6RO operation were posted on YouTube: **www.youtube.com/watch?v=K-cQ09H-LI8** (working KG5CCI)and **www.youtube.com/watch?v=Lg2QFB3ubRQ** (working WA6DIR & KL7CN/W6).

Thanks to Endaf Buckley, KG6FIY, for inviting me to give another presentation to the ARALB on March 4, and thanks to David Akins, N6HHR, for opening the W6RO station and allowing me to work the Queen Mary satellite station. 73!

Figure 4 — Patrick working AO-7 from W6RO.

Figure 5 — A successfully worked pass from W6RO!

eBay Sellers Donate to AMSAT

Are you an eBay seller? One item, ten items, or a full-time business you can donate a percentage of your winning bid to AMSAT. To do so, do not list your item with the basic listing tool, select advanced tools. eBay will give you a warning message that it is for large volume sellers, however this is where the eBay for Charity tool is found.

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Sometimes we are getting rid of our old equipment, sometimes selling something new. In any case, please consider giving a piece of the pie to a new satellite and choose AMSAT for your eBay Charity.

Phase 4: Big Science on an Amateur Budget

Eric Nichols, KL7AJ

Like countless other forward-thinking radio amateurs, I have been QWA (Quivering With Anticipation) for the impending launch and deployment of AMSAT Phase 4, in whatever form it eventually evolves into. For the first time in history, Phase 4 will give a large part of the Earth reliable 24/7 hour ham radio coverage without even having to refer to those pesky Kepler ephemeris data sets. Amateur satellite communication will be "set it and forget it." Much work remains to be done to make P4 a reality, not the least of which is the creation of an affordable, moderately standardized gateway to the bird. However, we know that, sooner or later and if all goes well, P4 will become a very reliable amateur radio utility. And therein lies the greatest danger. It is very likely that Phase 4 will work so well that amateur satellite communication could become boring.

I have been involved in radio, both commercially, and as a ham, for over 45 years. If I include my youthful electron twiddlings, I have well over 50 years of technology under my belt. But what has kept me interested in radio for all these years isn't so much the technology of radio, but the science of radio. I am far more fascinated by the fact that radio works at all than with the hardware and software, as impressive as they are, that allow us to use radio.

I was born and raised practically "down the snout" of the Stanford Linear Accelerator (SLAC). Our fifth grade class took a field trip to SLAC before it was even finished. Even in my youthful innocence, the sight of that behemoth kicked something alive in my being. Certainly, the hardware was impressive, even in its half-finished state. But what was even more captivating was the idea that minuscule particles could be slapped around with magnetic and electric fields to create entirely new universes, at least on some scale.

Of course, SLAC has long since been dwarfed by bigger atom smashers like the European Organization for Nuclear Research Large Hadron Collider (CERN). It is on my bucket list to visit CERN some day. I have been able to visit the facility vicariously, through my personal acquaintance with "Neutrino Man," David Saltzberg, who graciously wrote the forward to my ARRL tome, Radio Science for the Radio Amateur. Dave was present at CERN when the Higgs Boson particle first was officially detected. Dave is also the science consultant for the television situation-comedy, *The Big Bang Theory*, so he is the only officially famous science guy I know, at this time.

I say all that to say this: interesting science has long been associated with expensive science. I was closely associated with the High Frequency Active Auroral Research Program (HAARP) and its predecessor, HIgh Power Auroral Stimulation (HIPAS) Observatory, for many years. Both were big budget, big science facilities, to be sure. But we did a lot of ancillary science at these facilities that was not expensive or difficult. Basic plasma physics can be done on a kitchen counter.

We built a rather effective "sky in a jar" at HIPAS. Under controlled conditions there, we fairly reliably were able to reproduce phenomena such as long-delayed echoes and natural parametric amplification. But after the decommissioning of these sites, we were left with a lot of unfinished business. We were just beginning to understand some of the weirder aspects of ionospheric propagation. Unfortunately, basic research has always been a hard sell, and so much of the "small science" that we did at these facilities was dependent on the big science funding. When that went away, so did these marvelous, multi-tasking science facilities. (HAARP has been spared the wrecking ball, though much of the instrumentation has already been removed. HAARP has been slated for partial re-deployment later this year. Hope springs eternal). HIPAS, on the other hand, has been razed to the ground for a few years now.

AMSAT Phase 4 may be ideally positioned to resume some of these big science radio experiments. One of the most promising science packages for Phase 4 would be a topside (down-looking) ionospheric sounder, or ionosonde. To date, the only topside sounders have been deployed on short term, low orbiting satellites, or even shorter-term scientific rockets. A full time geostationary ionospheric sounder would be of great benefit not only for radio propagation prediction, but also for ionospheric science.

I will detail some of the challenges of such a topside sounder in a subsequent article. However, this is not the only possible science package. The interaction between the Sun and the Earth is extremely complex, loosely categorized as the magnetosphere. A large component of magnetospheric physics instrumentation is, not surprisingly, by means of magnetometers of various stripes. Land based magnetometers are familiar to any ham who obsesses over solar indices. But a satellite based magnetometer set could be even more useful from a pure science aspect. Such instrumentation could give us a larger view of our universe.

3-axis magnetometers already have been deployed on some CubeSats and MicroSats, but would be even more useful on a geostationary satellite such as Phase 4. These instruments are compact and inexpensive.

While I was working at HIPAS About 15 years ago, I attended a conference entitled, "Radio Detection of High Energy Particles," or RADHEP. It was actually at RADHEP where I first made acquaintance with Dave Saltzberg. The complete conference proceedings were bound in a beautiful blue hardcover book. Unfortunately, I have only one copy of that book, but would be glad to photocopy passages for anyone interested in this sort of thing.

RADHEP presented a wide variety of proposed methods of detecting exotic "free-ranging" particles by various radio methods, nearly all of them being ground based. Most of us know that the ionosphere shields us from a lot of these particles, which is both good and bad. The problem is that some of the more interesting particles, or potential particles, lose most of their energy (as well as their very essence) in passing through the ionosphere. A geostationary satellite-based particle detector is much more likely to detect these cosmological gems in their native state.

Not every particle detector has to be a CERN. Most of us have built crude cloud chambers in high school chemistry and physics classes. (At least most of us "seasoned citizens" did!) Perhaps we could adapt some of the RADHEP ideas for deployment on Phase 4 or subsequent AMSAT platforms.

As radio practitioners, hams have access to the Universe that few others have. I believe we have a golden opportunity with Phase 4 to not only "advance the radio art," but to make major contributions to basic science as well. While we need to know the questions folks are asking,, we hams have a long track record of having the right answers to the right questions. Phase 4 needs to be more than reliable. It needs to be exciting.

Goodbye to a Good Man and Former AMSAT President — Doug

Robert McGwier, N4HY
Board Member

Doug Loughmiller, W5BL, of McKinney, Texas, Past President of AMSAT and friend to many died on July 22, 2016, in Texas while fighting a brain tumor. His funeral was held on July 27 at Starrett Funeral Home.

He was friend to many in AMSAT and known to most hams in Texas. In recent years, he was one of the most active people in flying high altitude balloons in the country. Doug was founder of the Amateur Radio Balloons Over Northeast Texas (ARBONET) High Altitude Balloon club.

Doug was appointed AMSAT Vice President for Field Operations in 1987. In November 1988, at the board meeting associated with the annual meeting, Doug became the fourth president of AMSAT, succeeding Vern Riportella, WA2LQQ (SK).

Doug served as president, general manager, and executive director in that order until 1992, when he resigned to pursue other employment.

Shortly after Doug left the AMSAT executive positions, he joined Surrey Satellite Technology in Surrey, England, founded by Sir Martin Sweeting, G3YJO, where he worked for several years before returning to the United States.

He then pursued a successful career in the electronic component industry with Arrow Electronics, Future Electronics/FAI and finally RAM Electronic Sales, until he became ill. Doug was a field technical engineering consultant for all these firms.

Doug was a life member of the ARRL. In 2007, he was named "Instructor of the Year" for his work in teaching amateur radio licensing classes.

Doug married Danielle Catash (Danny) on May 4, 2001, in Paris, Texas.

He was preceded in death by his parents, and grandparents. Survivors include: his wife Danielle Loughmiller; two brothers, Deane and Dale Loughmiller, and his wife, Melanie; and a niece, Lindley Loughmiller — all of Paris; an aunt, Phyllis Freeman and husband Harold of French Lick, Indiana; an uncle, John Loughmiller and wife Donna, of Covington, Kentucky; numerous cousins; and his loving canine companions, LeRoy and Boudreaux.

Doug Loughmiler, W5BL, and his wife Danielle in the last known picture of him

40th anniversary of AMSAT celebration October 9, 2009. Left to right: Perry Klein, W3PK, Tom Clark, K3IO, Doug, W5BL (SK), Bill Tynan, W3XO, Keith Baker, KB1SF, Robin Haighton, VE3FRH, Rick Hambly, W2GPS, and Barry Baines, WD4ASW, the current president.

I personally kept in touch with Doug until close to the end and his spirits were always high. He put up a real fight, which in the end, he did not win.

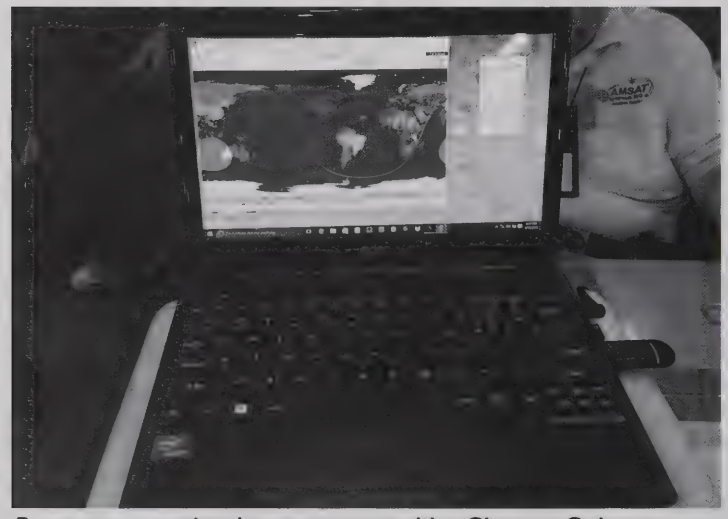
Doug will be missed by all of the people whose lives he touched. I know we will all wish him God speed on his high altitude flight where we are certain he is exploring something new as he did in a fearless way his entire life.

W5BL (SK) de N4HY

Ham-Com June 10-11, 2016 — Irving, Texas

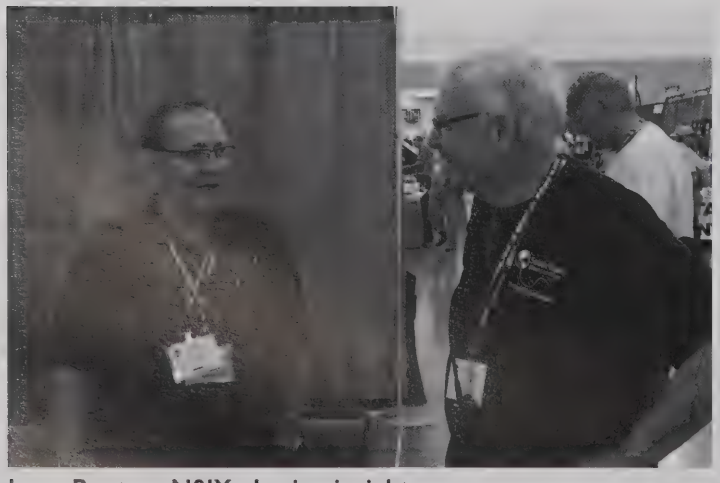
AMSAT President, Barry Baines, WD4ASW, and Glenn Miller, AA5PK. [All photos Joe Kornowski, KB6IGK.]

Clayton Coleman, W5PFG , operating his home satellite station from his laptop.



Remote operation laptop app used by Clayton Coleman, W5PFG, at AMSAT booth.

Satellite demonstration area outside Irving Convention Center.



Jerry Buxton, N0JY, sharing insights.

Dave Swanson, KG5CCI.

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Support AMSAT

AMSAT is the North American distributor of SatPC32, a tracking program designed for ham satellite applications. For Windows 98, NT, ME, 2000, XP, Vista, Windows 7, 8/8.1 & 10.

Version 12.8c is compatible with Windows 7, 8/8.1 & 10 and features enhanced support for tuning multiple radios.

Version 12.8c features:

- SatPC32, SatPC32ISS, Wisat32 and SuM now support rotor control of the M2 RC-2800 rotor system.
- The CAT control functions of SatPC32, SatPC32ISS and Wisat32 have been expanded. The programs now provide CAT control of the new Icom transceiver IC-9100.
- The main windows of SatPC32 and SatPC32ISS have been slightly changed to make them clearer. With window size W3 the world map can be stretched (only SatPC32).
- The accuracy of the rotor positions can now be adjusted for the particular rotor controller. SatPC32 therefore can output the rotor positions with 0, 1 or 2 decimals. Corrections of the antenna positions can automatically be saved. In previous versions that had to be done manually.
- The tool "DataBackup" has been added. The tool allows users to save the SatPC32 program data via mouse click and to restore them if necessary. After the program has been configured for the user's equipment the settings should be saved with 'DataBackup'. If problems occur later, the program can easily restore the working configuration.
- The rotor interfaces IF-100, FODTrack, RifPC and KCT require the kernel driver IOPort.SYS to be installed. Since it is a 32-bit driver it will not work on 64-bit Windows systems. On such systems the driver can cause error messages. To prevent such messages the driver can now optionally be deactivated.
- SuM now outputs a DDE string with azimuth and elevation, that can be evaluated by client programs. Some demo files show how to program and configure the client.

Minimum Donation is $45 for AMSAT members, $50 for non-members, on CD-ROM.
A demo version may be downloaded from http://www.dk1tb.de/indexeng.htm
A registration password for the demo version may be obtained for a minimum donation of $40 for members and $45 for non-members.
Order by calling 1-888-322-6728.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.

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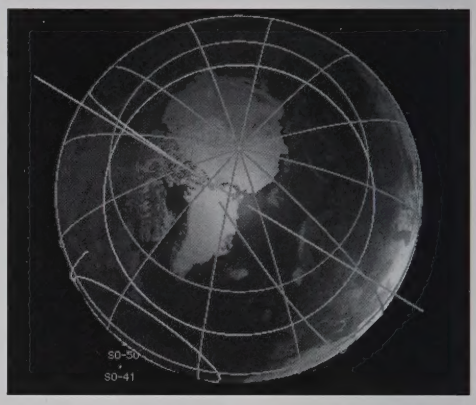

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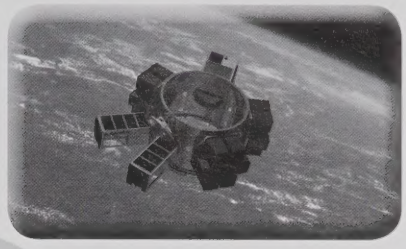
AMSAT Fox-1Cliff & Fox-1D $125,000 Launch Initiative Goal

AMSAT is excited to announce a launch opportunity for **BOTH** the Fox-1Cliff and Fox-1D Cubesats. In response to a breaking opportunity, AMSAT and Spaceflight, Inc. have arranged for Fox-1D to accompany Fox-1Cliff on the maiden flight of the SHERPA system on a SpaceX Falcon 9 in the 1st quarter of 2016.

Fox-1Cliff and Fox-1D will provide selectable U/V or L/V repeater capabilities on separate frequencies once in orbit, and will be capable of downlinking Earth images from the Virginia Tech camera experiment.

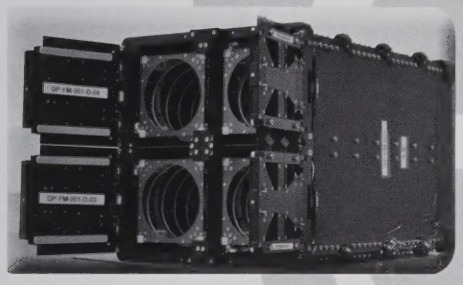
AMSAT has an immediate need to raise funds to cover both the launch contract and additional materials for construction and testing for Fox-1Cliff and Fox-1D. We have set a fundraising goal of $125,000 to cover these expenses over the next 12 months, and allow us to continue to keep amateur radio in space.

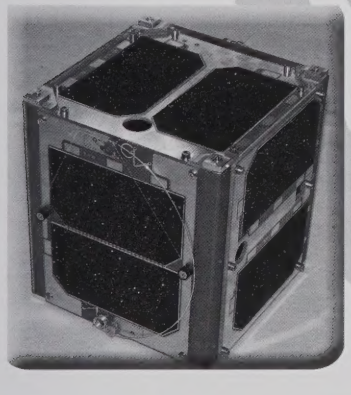


Spaceflight's SHERPA will deploy multiple cubesat payloads on-orbit

Spaceflight's SHERPA System

ISIS QuadPack Nanosatellite Dispenser





Your help is needed to get the AMSAT Fox-1Cliff and Fox-1D 1U Cubesats launched on the Spaceflight's initial SHERPA flight in 1Q 2016.

For the latest news on Fox-1 watch our website at www.amsat.org, follow us on Twitter at "AMSAT", or on Facebook as "The Radio Amateur Satellite Corporation" for continuing news and opportunities for support.

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AMSAT President's Club Support Fox-1Cliff and Fox-1D

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Silver Donors contribute at least US $50 per month	❒	$50 / month
	❒	$600 one time
Bronze Donors contribute at least US $25 per month	❒	$25 / month
	❒	$300 one time
Core Donors contribute at least US $10 per month	❒	$10 / month
	❒	$120 one time

AMSAT is Amateur Radio in Space ... and YOU are AMSAT!

Seize opportunities to launch your amateur radio experience to new heights!

ARISS Development and Support

AMSAT's Human Space Flight Team is looking for volunteers to help with development and support of the ARISS program:

- Mentors for school contacts
- Support for the ARISS web
- Hardware development for spaceflight and ground stations
- Help with QSL and awards certificate mailing.

To volunteer send an e-mail describing your area of expertise to Frank Bauer at: **ka3hdo@amsat.org.**

AMSAT Internet Presence

AMSAT's information technology team has immediate needs for volunteers to help with development and on-going support of our internet presence
:

- Satellite status updating and reporting.
- Add/delete satellites to ANS and the web as needed.
- Research and report satellite details including frequencies, beacons, operating modes.
- Manage AMSAT's Facebook and Twitter presence.

To volunteer, send an e-mail to Drew Glasbrenner, KO4MA at: **ko4ma@amsat.org**.

AMSAT Engineering Team

AMSAT Engineering is looking for hams with experience in the following areas:

- Attitude Determination and Control, and Thermal Engineering, to help in the design of high orbit CubeSats.
- Power systems, for CubeSats from 1U through 6U and LEO to HEO.
- Help with solar, power supply, and battery design for both LEO and HEO missions.
- Logistics, for parts procurement, inventory, and distribution.
- Documentation, for designs, tests, and public relations.

To volunteer, please describe your expertise using the form at **ww2.amsat.org/?page_id=1121.**

AMSAT User Services

AMSAT is looking for an on-line store co-manager to update and refresh the AMSAT Store web page when new merchandise becomes available or prices and shipping costs change.

- Add new merchandise offerings
- Delete merchandise no longer available
- Update shipping costs as needed
- Add periodic updates for event registrations
- Interface with the AMSAT Office

To volunteer, send an e-mail to Joe Kornowski, KB6IGK at: **kb6igk@amsat.org**

AMSAT Educational Relations Team

AMSAT's Educational Relations Team needs volunteers with a background in education and classroom lesson development ...

- Engage the educational community through presentations of how we can assist teaching about space in the classroom.
- Create scientific and engineering experiments packaged for the classroom.
- Create methods to display and analyze experimental data received from Fox-1.

To volunteer send an e-mail describing your area of expertise to Joe Spier, K6WAO at: **k6wao@amsat.org**.

AMSAT Field Operations

AMSAT's Field Operations Team is looking for satellite operators to promote amateur radio in space with hands-on demonstrations and presentations.

- Promote AMSAT at hamfests
- Setup and operate satellite demonstrations at hamfests.
- Provide presentations at club meetings.
- Show amateur radio in space at Dayton, Pacificon, Orlando Hamcation.

To volunteer, send an e-mail to Patrick Stoddard, WD9EWK at: **wd9ewk@amsat.org**

You can find more information on the web:
www.amsat.org – click AMSAT – then click Volunteer